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British Engineers and Egypt.

PRIVATE advices we have recently received from Egypt serve to demonstrate the lamentable fact that British manufacturers are by no means aware of the extensive openings for business in that country. At the present time, French, German, Belgian, and Italian firms are undoubtedly securing most of the orders given out by the Government departments and private firms, chiefly because they make it a practice to send representatives, and to appoint local agents to look after business. Electric tramway and electric-light installations are, almost without exception, carried out by continental firms. It is true that tramways are only required in a few large cities, but electric-light is now being installed in towns and villages all over the country, and if our electricians would only bestir themselves, they should certainly be able to participate in the work.

To show what foreigners are doing, we may mention one instance. At Luxor, an energetic Frenchman has built some hotels, and he naturally looked to his own country for an electrical engineer when the question of light had to be dealt with. Presently, we find a French electrician in charge of the contracts, and, being on the spot, this enterprising foreigner was able to secure other work, including the lighting of six of the Royal Tombs at Thebes. This experimental installation has proved very successful, and we believe that the remainder of the buildings will be artificially lighted, most probably by the same contractor.

British firms have absolutely no chance of obtaining such contracts so long as they adhere to their stay-at-home policy.

In the construction of cement and concrete steel buildings and drain pipes, we find the local agents of French and German firms have an absolute monopoly. Great activity is being displayed by the Director-General of Towns and State Buildings. New work is being undertaken on an extensive scale, and old buildings are constantly being repaired and altered, and yet British firms secure practically no benefit. The recently completed system of rain-water drainage for Cairo involved an immense amount of work, which went almost entirely to foreigners. The root of the evil appears to be the unwillingness of British manufacturers and contractors to enter the market and to cater for the needs of the country. In the case of rolled-steel sections, Germany and Belgium carry all before them, because makers are willing to roll material of the quality demanded. What the country wants is cheap material, and if our own makers will not supply this, orders must go elsewhere. This remark applies to practically all the engineering products used in connection with public and private building operations.

As for lifts and hoists, we are advised that British makers are absolutely unknown in Egypt, and that all the lifts required are supplied by continental firms, chiefly from Italy.

Those engaged in the septic treatment of sewage are also neglecting valuable opportunities. At the present moment a movement is on foot for the establishment of a comprehensive sewage system in Cairo, where nothing of the kind now exists. Here is a grand chance for some enterprising firm to send a representative or to appoint a really competent agent to exploit the capital. Our latest information is that British firms have already been approached on the subject, but that owing to their conservative methods negotiations have been opened with a French firm, who, having an accredited agent on the spot, are taking up the matter with alacrity, and have the advantage of being first in the field.

Turning to other departments of engineering work, we may say that, owing to the cattle plague prevalent this year, cattle are dying in thousands all over Egypt, and, if our manufacturers will take time by the forelock, it should be possible to sell steam ploughing machinery and steam pumps in large quantities. The pumps required are chiefly those of small sizes, to take the place of primitive contrivances for raising water from wells, and driven from time immemorial by rude ox-gears. We doubt if the mere despatch of catalogues will do much good. Personal representation is certainly advisable if success is to be attained, and if lacking the harvest will go to foreigners as usual. One correspondent says: "It is extraordinary how readily foreign firms send good agents to look after business, while our own firms seem quite unwilling to do so."

Finally, we may say, in connection with large centrifugal pumps for irrigation work, that Swiss pumps appear to be making great headway. They are described as being far more satisfactory and far better made than British apparatus of the same class. This opinion emanates from an English engineer of high standing, who shares with us the desire to see British manufactures of all kinds more worthily and more fully represented in Egypt.

Single-Phase Traction Motors.

Most alternating-current generators in commercial use are single-phase machines having their field magnets separately excited from a small continuous current dynamo. To run such a machine as a motor a continuous current must still be supplied to its fields, and its armature must revolve at a speed synchronous with that of the generator, that is to say, at the same speed when both machines have the same number of poles. At any other speed the motor soon comes to rest, so it cannot start itself, loaded or unloaded, but has to be speeded up by some external means before the load is switched on. For these reasons the synchronous single-phase motor has as yet found little, if any, practical application.

A series-wound continuous-current motor only needs to be furnished with a laminated field to work with single-phase alternating current, but it was found that at the frequencies most generally available —50 to 100 alternations per second—the output per weight and size is very low, the efficiency very poor and the sparking at the commutator excessive.

Repulsion motors invented by Elihu Thomson, are of the single-phase alternating-current type. Only the field circuit, which has a laminated core, is connected to the supply mains. The armature is wound and connected to a commutator just as in a continuous-current machine, but the two brushes are displaced about 45 degs. from the neutral line and short circuited together. This cross connection between parts of the winding at different potential allows induced currents to flow, and these re-acting with the magnetising flux set the armature in motion. These machines have a good starting torque, but it decreases rapidly with speed and their running performance is not satisfactory, their efficiency and power factor being

low and the sparking at their brushes difficult to keep within reasonable limits. Finally, there is the single-phase induction motor, also with a laminated cored field or stator, whose winding is connected directly to the mains quite independently of the armature or rotor. The winding of the latter is brought out to two slip-rings, so that, at will, external resistance may be put in series or it may be short-circuited. In its simplest form this motor is not self-starting, and only by means of a special winding or the stator combined with a phase-splitting device and a resistance in series with the rotor can it be put in motion, and even then takes an excessive current in proportion to the torque exerted. Nevertheless, it is the only type which has received any considerable application as a stationary motor for working off the mains of single-phase circuits.

This brief summary of what were considered to be the inherent characteristics and defects of all single-phase motors about which we had any practical information to within the last year or so, would not suggest that they are the least suitable, or stood any chance of being considered for heavy traction purposes, and polyphase working seemed to be the only system which might rival that now in use. With remarkable suddenness, however, opinion is undergoing an entire change. It is now pretty generally admitted that the ultimate system for long-distance traction with heavy loads at high speeds must be one in which high-pressure current is transmitted direct to the trains from a single conductor; for otherwise the first cost of line equipment, the losses in distribution, and the difficulties of current collection may prove prohibitive. This at once rules out continuous current, because the commutators of the motors could not stand the high voltage, and polyphase current, on account of the double or treble conductors necessary. Single-phase current exactly meets the requirements, if only a suitable motor is forthcoming; and the endeavours that engineers, all the world over, have been making for some time past to solve the problem have already yielded some most promising results.

One line of development has been in the direction of a combined repulsion and induction motor, so that the good starting properties of the former might be added to the loaded performance of the latter. The main idea is a comparatively old one. In some designs—as, for instance, the Arnold motor—all the commutator segments of the rotor are short-circuited by a centrifugal device after a certain speed has been attained. In another arrangement employed by Cramp, Fynn, and in the Schüler-Ferranti motor, slip rings are connected to the rotor windings at the end opposite to the commutator, as in a rotary converter; and between these resistance is inserted at starting and gradually short-circuited as the motor gathers speed. In this way a perfectly uniform transition from the repulsion to the induction principle is effected and a good torque is obtained throughout, so that the machine starts under load without absorbing an abnormal current. In other respects such motors are still far from perfect, for they have a low efficiency and power factor and a small overload capacity; nor, being of the constant-field type, do they possess any of the automatic speed regulating properties of the series motor. For these reasons the repulsion-induction motor is hardly yet suitable for traction purposes, although it may find a large sphere of usefulness in other directions, and be capable of still further improvement in the future.

At the moment the series motor, suitably modified for alternating current, appears to be the type which is going to meet traction requirements most completely, and upon which most attention is being concentrated, either in its simpler form as designed by Lamme for the Washington, Baltimore and Annapolis Railway and by Finzi for the Milan tramways, or else in combination with the repulsion principle as in the motors of Latour and of Winter-Eichberg. It is impossible to point to any one new feature which has enabled a type of machine that formerly seemed quite hopeless for the purpose in view to be converted into one of so much promise; rather is it a combination of modifications in design due to larger experience and knowledge that enables such improved

results to be obtained. The machines now under consideration have certain characteristics in common. They are all intended to be worked at a frequency not exceeding 15 to 25 alternations per second, and means are adopted for neutralising the armature reaction and keeping the reactance voltage of the armature coils as low as possible. Finzi divides his pole pieces longitudinally and inserts a german-silver resistance between each armature coil and the commutator, so that when it is short-circuited by the brushes and acting as the secondary of a transformer under the alternating flux due to the field, the current flowing is a minimum. His motor under test gave a power factor of over 80 per cent., except at the lowest speeds, and an efficiency averaging about 70 per cent., while he claims that the sparking at the commutator in no wise exceeded that in a standard continuous-current series motor running under similar conditions. No details have as yet been published of the design of the Lamme motor, but according to curves given for a 100-h.p. machine the power-factor and efficiency are both close about 90 per cent., and it is said to be practically sparkless.

In the Latour and Winter Eichberg motors, besides the brushes for conveying the main current into the motor there is another pair of short-circuited brushes at 90 degs. from the series brushes. Their effect is to so modify the paths of the current flowing in the armature and the resultant flux, that a power factor approaching unity is realised at all loads and sparking at the series brushes is eliminated. There is now, however, a tendency to sparking at the short-circuited brushes except at synchronous speeds, but this can be dealt with by attention to the details of design as mentioned above. Both makes of motor may have their stators connected direct to the high-pressure mains in the Winter-Eichburg machine, the stator has in series with it the primary of a transformer whose secondary supplies current at about 200 volts to the rotor as already described, so that, although in effect a series machine, there is no conductive connection between the stator and rotor. For the plain series machines of Lamme and Finzi, the high-pressure current has to be stepped down before it reaches them, and this is in one respect a serious disadvantage, as it adds to the equipment the weight and cost of a transformer capable of dealing with the whole of the power; but on the other hand it is questionable whether it is not better in the long run to confine the high pressure to an apparatus which can be more thoroughly insulated and protected than any portion of the motor itself.

It is certain that if anything like the claims made for these various single-phase series motors can be substantiated in prolonged working, they will at once and very materially expedite the introduction of electric traction in cases where it would not otherwise be feasible. It must be remembered that while possessing all the flexibility of the continuous-current series motor in adapting their torque to varying speeds and loads, their suitability to voltage control from a transformer when starting and stopping avoids all rheostatic losses at these times, and enables them to economise energy, which largely makes up for their somewhat inferior running efficiency. The only matter, and that a vital one, regarding which it seems possible their designers may have proved over-sanguine, is the effectual elimination of the commutation difficulties, for it so often happens that an amount of sparking, which is considered to be negligable on trial runs, proves disastrous in practice when the commutator and brushes get worn and dirty.

There is another method of applying single-phase motors to traction, and consists in always running them at their normal load and speed, but supplementing their power from auxiliary apparatus when excess loads have to be dealt with and restoring this power when the work demanded of the locomotive is below the normal, and even continuing to run the motor in the same way while the train is at rest. An ingenious system of this kind has recently been described in detail by Mr. B. J. Arnold, and would by now have been put to the test on a line in Michigan but for an unfortunate fire which destroyed the locomotive. The

motors were of the ordinary single-phase induction type, and the interest really centres about the auxiliary power—in this case compressed air—and the appliances for utilising it. Another system similar in principle, that is said will be demonstrated on a practical scale very shortly, employs storage cells as the auxiliary agent; but all such arrangements only seem to simplify the motor troubles by locating them in the accessory apparatus instead. What is really necessary for a completely successful scheme of traction with the motors always running at constant load and speed, is a practical variable speed-gear which can give any ratio of torque and speed between wide limits; and this alone seems a more difficult problem than the evolution of the ideal single-phase traction motor.

Education of Engineering Apprentices and Pupils.

THERE have been many signs of late that the employers of this country are at last awaking from their old state of indifference to education, and are beginning to recognise that it is to their own interest, no less than to that of their servants, to foster a love of learning, and encourage habits of study among their employees. It has sometimes been said by employers that what they wanted was men or lads who could use their hands, and do what they were told, and if such servants were obtained, it mattered little what their education might be, or what they did when the day's work was done. But this view overlooks the fact that the training and discipline of the mind of a man make him a better servant in every way than he was before, and that intelligence is always a *desideratum*, no matter how lowly the employment. This truth is now more fully recognised, and on all sides we hear the cry of the need for better education of the workers of the country. That is something gained, and the next step is to consider how this better education is to be given; and if we examine the conditions under which our industries are carried on, it becomes obvious that unless the employers enter heartily into the project, a very large and important section of the community must be left untouched. However well equipped our colleges and universities may be, only the better classes can afford to send their sons there, and the artisan class must go on sending their children to work at an early age that they may learn a trade and become wage-earners. The question is: Can anything be done to assist these young apprentices to continue their mental training after they have left school, to encourage them to have an ambition to rise, and to equip them so that they may take an intelligent interest in their craft?

An important document bearing upon this question has recently been published as a Report by the Educational Committee of the North-East Coast Institution of Engineers and Shipbuilders. Several of the leading engineers of the district were members of this Committee, and there is, therefore, great hope that the scheme recommended will be adopted largely by employers, and will receive a fair trial. We trust this will be the case, as there are many excellent suggestions in the plan formulated by the Committee.

The report deals with two classes of persons, (1) "apprentices," *i.e.* those who enter works to learn a trade, and whose object is to qualify as tradesmen, mechanics or artisans; and (2) "pupils," *i.e.* those who enter works with the object of fitting themselves to rise into the higher branches of the profession of engineering or shipbuilding, and who have attended, or will attend, a systematic course of instruction at day classes in a University.

With regard to apprentices, the Committee recommends that preference be given to those who bring the best certificates of conduct and character, and the highest school-leaving certificates. The age of starting should be from 15 to 16 years. In the works, a system of marking is recommended, and as high marks lead to promotion and increased pay, the apprentices will have a direct incentive to aim at the highest possible self improvement. For each examination passed during the year in some scientific subject,

20 marks will be awarded; for time-keeping, a maximum of 40 marks; and for good conduct, perseverance and progress in the workshops, a maximum of 40 marks. An apprentice obtaining 60 marks will receive an increase of wage of 6*d*. per week; 120 marks brings an increase of 1*s*. per week, and for marks between these limits a corresponding increase will be given. No increase is given unless 60 marks be obtained, and apprentices who fail to obtain any marks for time-keeping, perseverance, or good conduct, will be liable to dismissal. There is the further important recommendation that if an apprentice receives high marks for passing examinations at evening classes, and also for progress in the works, he may be allowed to spend his fourth or fifth year of apprenticeship at college day classes—the fees being paid by his employer. At least one vacancy per annum in the drawing office is to be filled by an apprentice obtaining the highest marks under the scheme.

We believe that if this scheme—or one like it—were widely adopted by employers, excellent results would be produced. The apprentices would have something to work for, and would be provided with the opportunity of advancement now too often absent. As the marks would be examined by the employers personally, they would be led to take a direct personal interest in lads of promise, and the relations between employer and employed would become more friendly. We would also express the hope that where an apprentice showed very special ability, the employer would consider the feasibility of advancing him even beyond the scale provided in the scheme, so that he might earn a living wage even before his full term of apprenticeship is completed.

The regulations for pupils comprise three schemes, each suited to a particular section. For those who have attended a three years' college course and have obtained pass certificates or a degree in engineering science or naval architecture, a three years' pupilage in the works is provided, the pay in the first year being the same as that of the ordinary apprentice of the third year, but being increased in the second and third years by 4*s*. and 7*s*. per week instead of 3*s*. and 5*s*. Youths who desire to follow the "sandwich system" will have a pupilage of six years, three of which must be spent in attending the degree course of study at a university college. The pay is that of ordinary apprentices plus 4*s*. per week in years subsequent to their first year's college training. Finally, a scheme is given whereby those who originally enter as apprentices, but, after entrance, succeed in passing the matriculation or equivalent examination prescribed under the last-mentioned scheme, will for the remainder of their term be treated as pupils under that scheme in respect of leave to attend college day classes, promotion, and rates of pay. The time served, including that spent at college, will be a minimum of six years. Under this scheme preference is to be given to sons of workmen and other employees of the firm.

These regulations are also excellent, the only drawback we see being that under the third scheme, while sons of artisans may become pupils instead of apprentices on showing great ability, they may not be able to take advantage of the privilege of attending day classes at college, as even their pupil wage is not a living wage, and their parents are probably poor. It is greatly to be desired that some means of assisting such promising youths to attend college classes should be found. Of course scholarships may be won, and these will serve the purpose, but the number of scholarships is limited, and they will, as a rule, be gained by students who have had a high-school education.

We welcome this report as a sign of progress, and as a meritorious attempt to deal with a highly important matter. We shall be interested to see whether the recommendations are widely adopted in the North Eastern district, that great centre of engineering, and to learn the results produced by their adoption.

The Economical Use of the Steam Jacket.

ALTHOUGH steam jackets have been used on the cylinders of steam-engines almost since the first steam-engine was made, and although of late years many tests have been made, both in the laboratory and with power-plants, to determine the degree of economy due to the use of steam jackets, yet at the present time opinion in the engineering world is sharply divided as to whether steam jackets are, or are not, an advantage.

Certainly the tests have given such widely differing results — indicating in some cases an economy of up to 30 per cent. due to the use of jackets, and in other cases showing an absolute loss due to the jackets—that this state of affairs is not to be wondered at, and it would be well to carefully consider under what conditions a steam jacket may, or may not, conduce to economy.

And, in the first place, to consider why a steam jacket should be desirable on a cylinder. Suppose dry saturated steam to be admitted to the cylinder of a steam-engine which has no jacket. The cylinder walls, being at a lower temperature than the steam, will condense some of the steam, until the latent heat thus liberated raises the temperature of the walls up to that of the steam. Part of this condensed steam will form a film of water on the cylinder walls and on the valve seats with which it is in contact.

If, now, steam is cut off in the cylinder and is allowed to expand, falling in pressure and consequently in temperature, and doing work, this work will be done at the expense of part of the heat in the steam. The steam would thus be reduced to a temperature lower than that corresponding to its pressure, but that part of the steam is liquefied, the latent heat thus liberated keeping the remainder of the steam at the temperature corresponding to its pressure. Part of this condensed steam will also form a film on the cylinder walls.

The cylinder walls, being in contact with steam which varies considerably in temperature during each cycle, will also vary in temperature during each cycle, though it was proved by Messrs. Callender and Nicholson—in a series of experiments, the results of which were communicated to the Institution of Civil Engineers in 1895—that the fluctuation in temperature of the cylinder walls is very much less than that of the steam with which it is in contact; so that at the end of each stroke the temperature of the walls will have fallen with that of the steam, and we shall consequently have cool walls to receive the incoming steam at the beginning of the next stroke.

As a result of cool walls and of adiabatic expansion we are thus left with a film of water on the walls of the cylinder and on the valve faces.

Next let us consider the effect of this film of water—how it may affect the economy of the engine.

It has been shown experimentally that, however well a valve may fit on its seat when cold, so that when at rest no leakage of steam takes place past the valve, yet when in motion leakage—often considerable leakage—takes place. This was also proved in Messrs. Callender and Nicholson's experiments.

Now it is very highly probable that this

leakage is due mainly to the presence of this film of water on the valve-seating and valve faces, and that it takes place by a system of condensation and re-evaporation on those surfaces. The valve-surfaces, cooled by being in contact with the exhaust steam in the exhaust passages, when coming in contact with high-pressure steam condense part of this steam as a film on the valve. When the valve again covers the exhaust passages this film is re-evaporated, the steam thus escaping directly into the exhaust passage without doing any work in the cylinder.

As the back pressure in the cylinder is also increased by this leakage, it is particularly wasteful.

Again, it is well known that there is a much greater leakage of wet steam through a crack—other things being equal—than of dry steam, due to a similar breaking-up of the water film.

Now, it is very probable indeed that, due to this same cause, there will be some leakage past the piston--considerably more than has generally been thought—which leakage will, of course, increase the back pressure in the cylinder, and militate greatly against economy.

It would therefore appear certain that, could this condensation on the cylinder walls be prevented, there would be much less loss from leakage of steam. But this film of water tends to lower the economy of the engine in yet another way.

During steam admission the steam which is condensed on the walls gives up its latent heat, part of which goes to maintain the remainder of the steam dry, while part goes to heat up the cylinder walls to the temperature of the incoming steam. During expansion the pressure and temperature of the steam falls, until at last the temperature of the walls is higher than that corresponding to the pressure of steam in the cylinder, and the film of water on the walls then begins to abstract heat from the walls and to be evaporated.

As, however, due to adiabatic expansion, there will be a liquefaction of steam up to the end of the stroke, we shall begin the exhaust stroke with a film of water on the cylinder walls.

The walls, being at a higher temperature than that corresponding to the pressure of the exhaust steam, will give up part of their heat in evaporating this water, causing an increased back pressure in the cylinder and a direct loss of heat to the condenser, and thus, in both ways, reducing economy.

Now heat is only transmitted slowly from a *dry* metal surface to dry steam with which it may be in contact, the presence of a film of water on the surface greatly helping the transmission, so that the presence of this film on the cylinder walls is in this way also a cause of loss.

Also, for the same reason, the presence of this film causes the fluctuation of temperature of the cylinder walls to be greater than would otherwise be the case. So that, for every reason it is important that the formation of this film of water on the cylinder surfaces should be prevented as far as possible. What conditions then are necessary in a steam jacket in order that we may be able to prevent this formation?

As a specific case, let us consider in detail what happens in the case of an engine having a single cylinder—double-acting, condensing—of 12 ins. diameter and 3 ft. stroke, and running at 100 revolutions per minute. Suppose steam at 100lbs. gauge-pressure to be used, cut off at half-stroke; and suppose the back-pressure of the engine to be 4 lbs. absolute.

From the result of experiments we know that the range of temperature of the surface of the cylinder walls will be approximately 10 degs. Fahr., and the heat necessary to cause this series of fluctuations per minute per square foot of cylinder-wall surface will be approximately 200 T.U.

If the engine is of the slide-valve variety the area of cylinder wall and of valve port surface will be about 19 sq. ft., so that the heat per minute which must pass through the cylinder walls from the jacket in order to prevent any condensation due to the fluctuation is roughly $200 \times 19 = 3{,}800$ T.U.

The heat per minute which must be given to the steam, in order to prevent any liquefaction due to adiabatic expansion is approximately 1,725 T.U., so that, assuming that roughly 50 per cent. of the heat given to the walls during initial condensa-

tion is given out again to the steam during the latter half of the forward stroke, and so does useful work in the cylinder, we see that, in order to prevent any liquefaction in the cylinder, due to any cause, the jacket must be capable of giving (1,725 + 1,900) = 3,625 T.U. per minute to the cylinder steam.

Now, assuming that the cylinder walls and ends are jacketed, we get a jacket area of, roughly, 11 sq. ft., and therefore we must pass heat at the rate of $\frac{3,625}{11} =$ 330 T.U. per square foot of jacket surface per minute through the cylinder walls.

But the rate at which heat will flow through a metal plate is proportional to the difference in temperature between the two sides of the plate, other things being equal. It is also inversely proportional to the thickness of the plate, and it is found that, with a wall thickness of 1 in., heat will pass through cast-iron at the rate of 3·8 T.U. per square foot per minute, so that the required difference of temperature between the two sides of the cylinder walls in our case will be $\frac{330}{3·8} =$ 86 degs. Fahr.

The mean temperature of the surface of the cylinder is approximately 280 degs., so that the temperature of the jacket steam must be 366 degs., corresponding to a gauge pressure of 150 lbs.

We thus see how important it is that the thickness of the cylinder walls should be kept as little as possible, in order that this necessary difference of pressure between the jacket steam and the initial cylinder steam may be made as small as possible. This is a point very seldom taken sufficiently into account in the design of jacketed cylinders.

So that, in order that a jacket may be causative of economical working, it is necessary that the temperature of steam in the jacket should be much higher than that of the steam in the cylinder.

For this reason we see that where steam is led from the boiler through the jacket of a high-pressure cylinder, before passing into that cylinder there will be little economy due to its use, if any, the temperature gradient between the two surfaces of the cylinder walls not being sufficiently great to allow of enough heat flowing through the walls to prevent liquefaction of steam.

One way of obtaining this necessary difference of temperature in the case of a high-pressure cylinder would be to pass the steam, after passing through the jacket, through a reducing valve, and then into the cylinder. The steam would be reduced in pressure and temperature by this process, but would be dried, and perhaps slightly superheated. As to whether this process would be economical or not is very doubtful, the gain due to reduced liquefaction in the cylinder being counterbalanced by the loss due to working with steam at a lower pressure. Another way of obtaining the necessary difference of temperature would be to place a reducing valve on the main steam-pipe, and to take the steam supply for the jacket of the high-pressure cylinder from the boiler side of the reducing valve, the steam jacket being drained directly into the boiler, where the respective height of cylinder and boiler gives sufficient head for this purpose.

This method would have the advantage of providing drier steam to the cylinder, the cylinder supply steam not coming in contact with the water condensed from the jacket steam.

Again, as the rate of transmission of heat from a gas to a metal surface with which it is in contact is proportional to $a + b\,v^2$, where a is a constant depending on the diffusivity of the gas, and where v is its velocity over the surface, we see that it is highly important to have a free circulation of steam through the jacket; and hence a jacket which is fitted, as so many are, with simply one steam inlet and a steam trap to drain off the condensed water, cannot be expected to prove very efficient.

To conclude — generally speaking, a steam jacket fitted to the high-pressure cylinder of a compound or triple-expansion engine, or to the cylinder of a single-cylinder engine, will not increase the economy to any appreciable extent. On the other hand, steam jackets fitted to the intermediate cylinder of a compound

engine, or to the intermediate and low-pressure cylinders of a triple-expansion engine, the jacket having a free circulation of steam at boiler-pressure through them, and being well drained, will undoubtedly lead to economy.

In a triple-expansion engine the low-pressure cylinder will most repay jacketing, as, by having dry steam during the exhaust-stroke of this cylinder, a much less quantity of heat is rejected to the condenser without doing work than would be the case if a film of water were to be formed on the cylinder walls.

As the amount of heat transmitted through a steam jacket is, other things being equal, proportional to the area of wall surface in contact with the steam, it is important to have the jacketed surface as large as possible. Therefore, the ends of the cylinder, as well as its barrel, should be jacketed.

Also, as the presence of a film of water on the valve seats causes a direct loss due to leakage of steam from one side of the valve to the other, the valve seats should, whenever practicable, be jacketed. This is particularly so in the case of a slide-valve or piston-valve engine, where the same valve serves for both high-pressure and exhaust steam.

In the case of a Corliss valve engine this leakage is not so important, as steam cannot leak directly through from the steam ports to the exhaust ports without doing work in the cylinder, as is the case with a slide-valve engine.

As the variation in temperature of the cylinder walls, due to a given variation in temperature of the steam with which they are in contact, is a function of the time of a cyclic change of temperature, the loss due to initial condensation will, other things being equal, be greater on a long-stroke, slow-speed engine than on a high-speed engine, and hence a slow-speed engine will derive more benefit from jacketing than a high-speed engine. Also, in a high-speed engine the ratio of cylinder surface to power developed is less than in a slow-speed engine; and consequently, in order to transmit the same amount of heat through the jacket per minute in the two cases, the difference in temperature would have to be much greater in the case of the high-speed engine.

The initial condensation will be less in the case of a high-speed engine, also because of this inequality of ratio of cylinder surface to power developed.

In the case of two engines, one cutting off steam much earlier in the stroke than the other, the fluctuation of temperature of the cylinder walls being proportional, roughly, to that of the steam, will be greater in the engine with the earlier cut-off. This will lead to increased initial condensation, and hence an engine with an early cut-off will derive more benefit from a steam jacket than will one with a late cut-off, other things being equal, so that in the case of a slow-speed engine cutting off early in the stroke, it would be economical probably to use a steam jacket even to the high-pressure cylinder; and this is the only case in which it is advisable to fit a steam jacket to the high-pressure cylinder of a double-acting engine.

In a single-acting engine, there will be an additional loss of heat by conduction along the cylinder barrel, and as one side of the piston is always in contact with the atmosphere, it is evident that, other things being equal, initial condensation will be greater than in the case of a double-acting engine. So that in single-acting engines—excepting those of specially high-speed—it would be advisable to jacket, with high-pressure steam, that cylinder which is open to the atmosphere.

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Carburators, Vaporisers, and Volatilisers used in Petrol, Alcohol, Kerosene, and Crude Oil Engines.

PETROLEUM, in its crude condition, is a dark, pungent liquid, of wide distribution, and owing to its comparative cheapness and ease of transport, is peculiarly adapted for the economical ge ieration of power. The oil, in its natural state, lends itself for use for power purposes in three distinct ways: (1) in specially constructed grates fitted with steam or compressed-air atomisers for steam raising; (2) in slow-combustion or caloric engines; (3) in explosion engines provided with suitable vaporisers or volatilisers. The only preparation needed is an efficient straining of the oil to ensure the removal of all suspended matter which otherwise would be liable to choke the pipes and clog the feed mechanism.

Owing, however, to the intense heat required for perfect combustion, the natural unrefined oil does not lend itself for use in explosion engines of small power, such as those used for the rapidly increasing motor road traffic, for river craft, launches, yachts, submarines, and for the vast number of stationary industrial engines of small power.

In order to obtain a suitable and safe oil for burning in illuminating lamps for domestic purposes, the natural crude oil is subjected to a course of distillation; the first distillates coming over from the still being the benzine series, comprising all the more volatile constituents, known variously, according to their degree of refinement, as gasoline, benzine, benzoline, mineral naphtha, mineral spirit, motor spirit and petrol. All these have a flashing point below the freezing temperature of water, and require no heat preparation to render a mixture of the vapour and air explosive. In consequence, special regulations are in force in most countries for their storage, distribution and transport. The weight of all the mineral spirit series is slightly less than three-fourths that of water, the range being from 650 to 750 s. p. g.; and owing to its much greater expansive nature, reservoirs and tanks should never be filled to more than nine-tenths their full capacity, to allow for increase of volume of the liquid, due to temperature variations in ordinary climates.

The ready volatilisation of all the series of mineral spirit at low temperatures makes it specially suitable for use in small high-speed explosion engines, such as are so very extensively used for road-motor traffic, and other purposes mentioned above. None of the spirit series, however, require any preliminary heating for use in the smallest engine, and can be readily volatilised by the simplest and crudest form of carburator or atomiser; the principal requirements being an apparatus capable of supplying a perfectly regular adjusted mixture of spirit vapour or atomised spray and air to the motor cylinder, under all conditions of load and speed.

Surface Carburators.

Class 1.—The method at first generally adopted was to supply, by means of a bye-pass to the main air-induction pipe of the motor, a proportion of vapour and air, generated from a sort of carburating tank or reservoir. Various means have been used in their turn, such as pumping or forcing air through and over the surface of the liquid—a method adopted in the early Benz, Daimler, and De Dion and other petrol spirit motors (*vide* Figs. 1 and 2). Carburation by saturated cotton and wire-gauze wicks has been also tried by many makers, and various forms of mechanically actuated stirrers and agitators; one early device used by Lenoir being a fine wire cage containing an

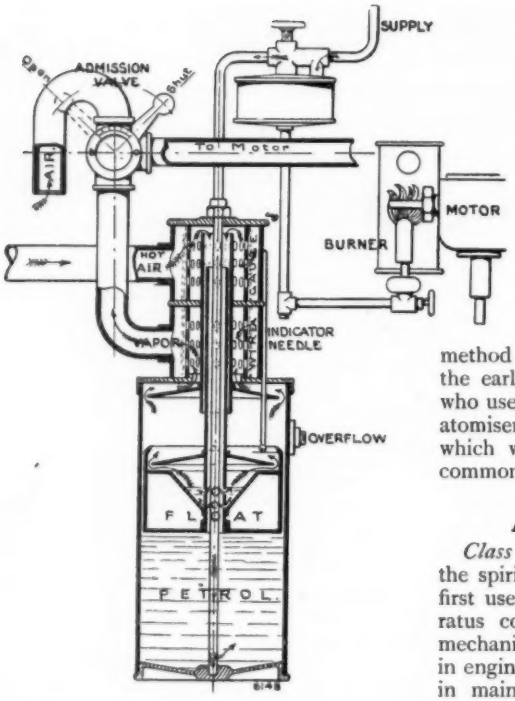


FIG. 1.—"DAIMLER" SURFACE CARBURATOR.

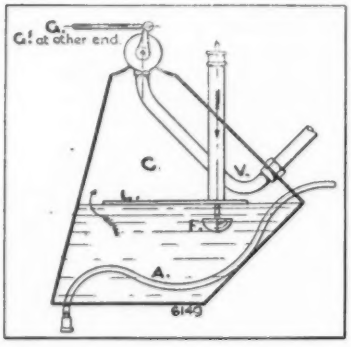


FIG. 2.—"DE DION" SURFACE CARBURATOR.
G Mixture Valve.
*G*¹ Air Valve.
C Carburating Chamber.
V Pipe to Cylinder.
F Air Supply Tube with Indicator.
L Baffle Plate.
A Small Pipe from Exhaust.

absorbent supplied with mineral spirit, and arranged to revolve at a high speed in a carburator chamber, the vapour being whirled out and caused to mix with the air, after the fashion of the housemaid's method of drying her mop. Other carburators under this class were the Delahaye, Lamaudière, Aster, Philips Lufbery, etc.

Compressed-air Atomiser-Carburators.

Class 2.—A more scientific method was that followed by Etève, one of the earliest adapters of the spray system, who used the combination of an air-pump, atomiser-nozzle, and volatilising chamber, which worked after the fashion of the common scent spray bottle.

Force-Pump Atomiser-Carburators.

Class 3.—The direct fluid injection of the spirit into the air-induction pipe was first used by Spiel (Fig. 3), whose apparatus consisted of a spirit pump with mechanically actuated valves. Difficulty in engines fitted on this system was found in maintaining the exact proportion of spirit and air required for a uniform degree of efficiency; in the packing of the pump plungers, so as to prevent leakage of the spirit; and in adjusting the exact proportion of liquid to obtain the best result. Frequent re-adjustment to compensate for the varying level in the supply tank was also necessary to compensate for the minute variations in the operating mechanism; so much so, as to be the exception, rather than the rule, for two engines to be capable of being adjusted to run through a brake test with uniform results. With the view of overcoming these drawbacks, and to adapt engines working on the throttle with a pump-feed carburator, the apparatus shown in Fig. 4 was devised. This consisted of a combined piston and pump plunger, arranged to force a jet of liquid into the carburating chamber exactly in proportion to the air supplied to the motor. Many and various mechanically operated measuring devices have been projected and experimented

with, such as, for example, a miniature form of cupped-chain elevator, recessed wheel valves, as in the early Gobron-Brillie motors (Fig. 5); sliding displacer rods, as in the Roots motor and many designs of pumps. In the Grob engine a glycerine bath is used for the plunger to work in—the object being the avoidance of leakage of the petrol spirit past the gland: in others, a diaphragm displacer requiring no packing was used. All these devices depend on perfect mechanism and careful adjustment; but the requisite uniformity of action is practically unobtainable when applied to the high-speed multi-cylinder motor.

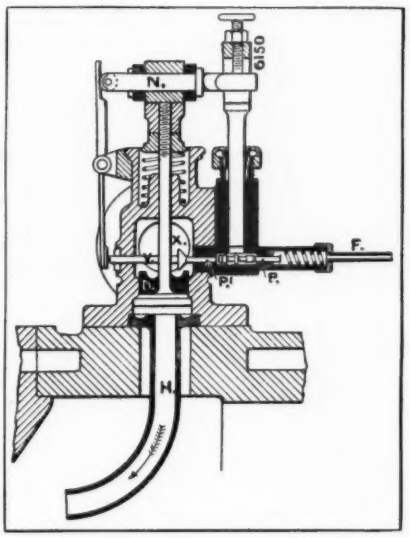


FIG. 3.—"SPIEL" PUMP CARBURATOR.

F Petrol Pipe. *X* Air Pipe. *H* Mixture to Cylinder.
N Plunger Cam Rod. *P* & *P*¹ Pump Valves.
V Governor Rod. *D* Induction Valve.

Gravitation-Feed Atomiser-Carburators.

Class 4.—This method—when used in conjunction with a mechanically operated timing-valve, and provided the engine is required to run at a fairly constant speed—has given fairly satisfactory results (Fig. 6), carburators of this type being used in many small stationary engines, and particularly in gasoline motors of American construction—their cost of manufacture being low, and action simple. There are, however, some objections to their application in cases where absolute automatic and self-adapting working is desirable, such as, for instance, liability to flooding on stopping of the motor, incapacity for variations of speed and, generally speaking, carburators of this type do not possess that nicety of adjustment and control necessary for a high-class spirit multi-cylinder motor.

The Pennington engine was worked on a hand-controlled gravitation feed. Gravitation feed carburators—when provided with a non-return spirit-valve to the atomiser nozzle so as to automatically control the feed, through the agency of an air piston or valve—give fairly satisfactory results in stationary and marine engines, and can be made to work well

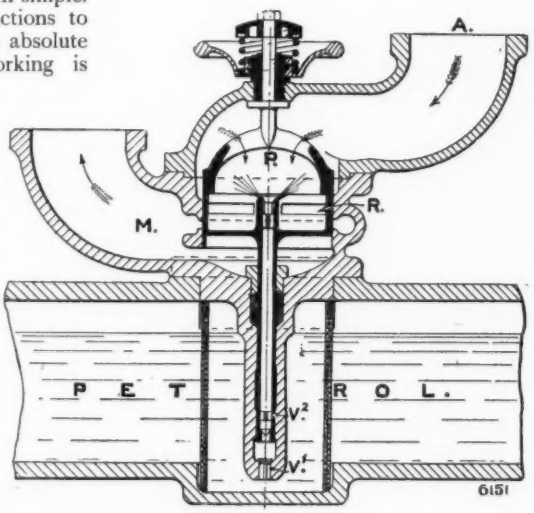


FIG. 4.—"BUTLER" PUMP CARBURATOR.

P Air Controlled Pump. *V*¹ & *V*² Pump Valves.
R Air Ports in Pump Piston. *A* Air. *M* Mixture.

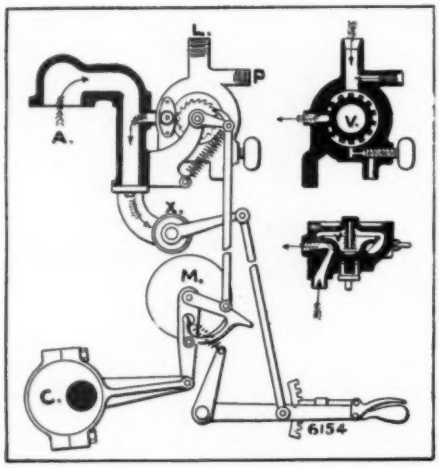


FIG. 5.—"GOBRON-BRILLIE" CUPPED-VALVE CARBURATOR.

V Cupped rotative Valve. *A* Air Inlet.
M Rotating Mechanism. *L* Alcohol Inlet.
C Cam Shaft. *P* Petrol Inlet.
X Regulator Valve.

on some car motors. In these cases, the carburator is provided with an adjustable petrol feed and air and mixture supply, each being arranged directly under the control of an intelligent driver. There have been some dozens of modified designs of gravitation feed-carburators, of which the three varieties illustrated by Figs. 7, 8, and 9 are fair examples.

Other carburators included under this class are the Aigle, Alderson, Blake, Constantine, Dalifol, De Sales, Dupuy, Endurance, Forman, Gautière-Wehrlé, Grove, Hulley, Iden, Kicheur, Kulstein, Lepape, Lucas, New, Oldsmobile, Pennington, Riotte, Roubeau, Star, Strelinger, Tourand, Union, Wolverine, etc., etc. All these show a marked similarity, and are nearly all provided with an induction or cam-operated feed, in combination with hand-controlled petrol, air and mixture valves.

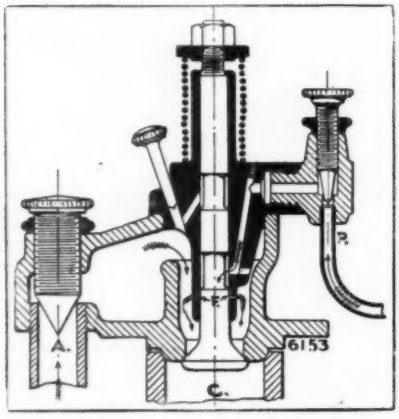


FIG. 6.—"CROSSLEY-HULLEY" GRAVITATION- OR PRESSURE-FEED CARBURATOR.

P Petrol Pipe. *A* Air Pipe.
F Petrol Feed. *C* Open to Cylinder.

Induction Jet Atomiser-Carburators with Constant Level Cisterns.

Class 5.—A combination of atomiser nozzle supplied with petrol from a small cistern, and maintained at a constant level by a float-regulated feed, which projects a jet of atomised spirit into the carburating chamber, and works in consonance with the pumping action of the motor piston; has survived all other methods and is now, in slightly modified forms, in universal use in all makes and types of petrol spirit motors. This class is generally known as the float-feed carburator, and is preferred to all others owing to its simplicity and absolute automatic action.

The earliest adaptation of this principle is the Butler float feed inspirator (Fig. 10), and the Maybach (which latter, in modified form, is better known as the Daimler), De Dion, and Longuemare. In combination with an air pulsator used in the inspirator, it is known as the Ader, Kreb, etc. (Figs. 11, 12, 13). This class of carburator is even superseding all others for small bicycle motors, as, when the component parts are carefully constructed, a carburator of this class readily lends itself to the maintenance of uniformity of action under the very trying conditions obtaining in a motor exposed to changing levels, speeds, and jolts as experienced in a fast

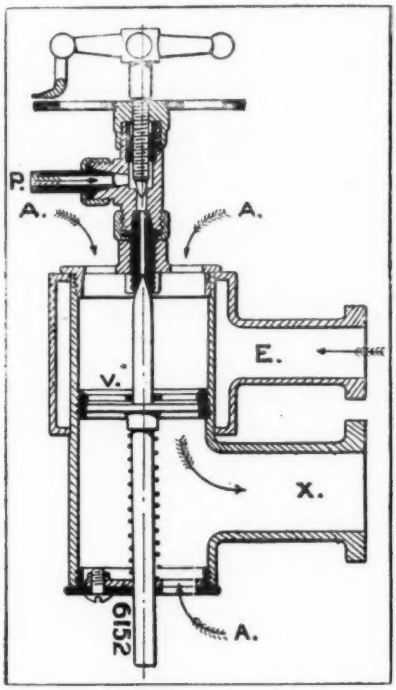


FIG. 7.—"ENDURANCE" GRAVITATION-FEED CARBURATOR.

P Petrol Pipe.
A Air-controlled Supply.
V Air-controlled Petrol Feed-Valve.
X Mixture to Cylinder.
E Exhaust from Cylinder.

automobile, and gives results under these conditions difficult to obtain by any other means.

Some of the modified forms of jet atomiser-carburators with float constant-level feed cisterns are the Abeille, Ader, Butler, Brooke, Cail, Crouan, Charly, Cottereu, Daimler, Dorey, Dunlop, De Dietrich, De Dion-Bouton, Eldin, Espinasse, Fillet, George-Richard, Goutallier, Jenatzy-Martini, Kreb, Le Blon, Longuemare, Maybach, Martha, Mors, Napier, Ormonde, Peugeot, Phœnix, Sanson, Sthenoss, Vaurs, Wilkinson, and others. It would serve no useful purpose to give illustrations of many of these, owing to their similarity of construction to the examples of this class of carburator illustrated herewith. A constant level in the supply-cistern can be obtained on the bird-fountain principle, and has been used for stationary engines; another means is by an overflow and pump, as used in the Duryea and Craig motors (Fig. 14).

Alcohol Carburators.

The remarks on mineral spirit carburation may generally be applied to alcohol spirit for use in small explosion engines with this difference, viz., that alcohol is more expensive and less efficient, but has an advantage over mineral spirit in tropical countries owing to less restrictions to transport. Some considerable encouragement has been given to the distillation of crude alcohol in France and Germany from beet, potatoes and grain to foster home agriculture, and many surprising results have been obtained in road-cars propelled by alcohol motors. In the tropical sugar-growing countries, India and South America, where alcohol can be cheaply distilled, it may, by possessing similar properties to the mineral spirit motor, become a serious competitor to the kerosene engine. In the successful

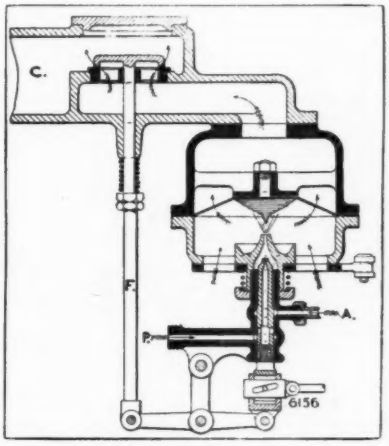


FIG. 8.—"IDEN" GRAVITATION FEED CARBURATOR.

P Petrol Pipe.
A Air Pipe.
F Air-controlled Petrol Feed.
C Mixture to Cylinder.

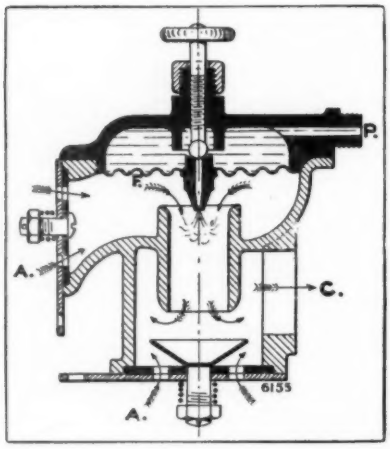


FIG. 9.—"BLAKE" GRAVITATION-FEED CARBURATOR.

P Petrol Supply. *F* Diaphragm Petrol Feed.
A Air Supply. *C* To Cylinder.

use of alcohol a higher compression in the cylinder is found necessary which, in its turn, would point to the advantage of a comparatively long stroke. The Gobron-Brillie double-piston engine, with a single combustion chamber, favours this view.

The carburator used, whether it be a form of gravitation feed or a constant-level feed, should be jacketed by an exhaust or hot-water chamber so that the comminuted spirit spray may be thoroughly volatilised and incorporated with the air supply. The temperature of the mixture need not be raised above 300 degs. Fahr. to obtain the most economical results; and, for facility in starting, a separate feed of petrol spirit should be used for a minute or so.

Economy and Super-carburation.

It is so easy to use more spirit than is essential for the power developed in the spirit motor, that the importance of a carefully regulated carburator—one that will give the critical degree of carburation under all conditions of speed and load—cannot be over-appreciated.

As there is in spirit engines, for any given compression, a critical mixture which results in the highest explosive pressure, a very little deviation above or below this degree will result in a greater proportionate difference of power developed for the quantity consumed. One may, with some carburators, frequently super-carburate the mixture so that a smoky exhaust with sooting of the igniter follows, resulting eventually in miss-ignitions and greatly increased deficiency of working.

The motorist may be heard to blame the quality of the petrol he is using—or at least this often used to be the case—but the fault, then as now, is more often due to the mismanagement of the motor by inexperienced adjustment of the carburant. An exactly graded mixture with accurately timed electric ignition are essential factors in the construction of a spirit motor, and are of even greater importance than large gas-tight controlling valves, well-packed pistons and carefully balanced and lubricated mechanism.

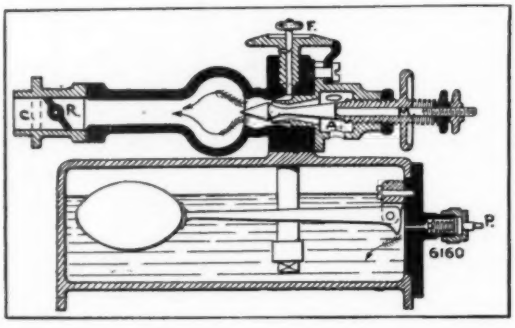


FIG. 10.—"BUTLER" FLOAT-FEED CARBURATOR.

P Petrol Supply. *R* Throttle Regulator.
A Air Supply. *M* Mixture Regulator.
F Petrol Feed. *C* To Cylinder.

Perfect Carburation essential to wide range of Speed Control.

The very perfect speed control of some of the modern petrol multi-cylinder motors, is obtained partly by an adjustable ignition and a well-

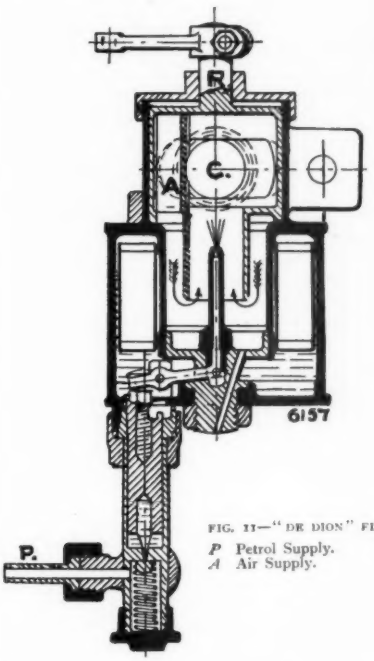


FIG. 11—"DE DION" FLOAT-FEED CARBURATOR.

P Petrol Supply. *R* Mixture Regulator.
A Air Supply. *C* To Cylinder.

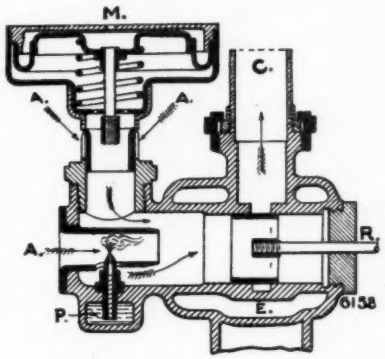


FIG. 13.—"KREE'S" FLOAT-FEED CARBURATOR.

P Petrol Supply. *R* Throttle Regulator.
A Air Supply. *E* To Exhaust.
M Mixture Regulator. *C* To Cylinder.

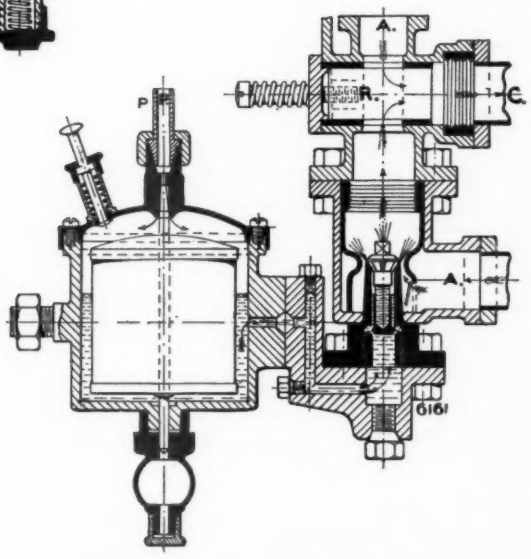


FIG. 12.—"LONGMARE" FLOAT-FEED CARBURATOR.

P Petrol Supply. *A* Air Supply. *R* Mixture Regulator. *C* To Cylinder.

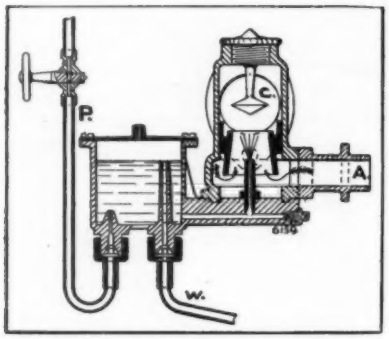


FIG. 14.—"CRAIG" FLOAT-FEED CARBURATOR.
P Petrol Supply. *C* To Cylinder.
A Air Supply. *W* Petrol Overflow.

governed throttle, but is principally dependent on a self-adapting form of carburator which will automatically and definitely carburate the air to form a mixture of an exactly predetermined degree under all conditions of temperature, load, and speed. To obtain this result a constant level must be maintained in the supply cistern, which in the De Dion engine (Fig. 11) is made to surround the atomiser jet so as to be entirely independent of the road gradients. The degree of induced suction caused by the variable flow of the air supply must be modified by an automatic air-plug or its equivalent, so as to adjust the sectional area of the air nozzle in proportion to the velocity of the current of explosive mixture to the motor cylinder.

[In a succeeding article, Mr. Butler will consider the volatilisers, vaporisers, etc., as adapted for use in internal combustion engines using heavy oils.—ED.]

E. BUTLER, M.I.Mech.E., A.M.I.E.E., etc.

Electric Rail Welding
On the Glasgow Tramway System.

An interesting experiment has been for some time in progress on the Glasgow Municipal Tramway system—an experiment which is being watched with the greatest interest by engineers and steel makers, as well as by all concerned with tramway and railway mechanics. Since the Corporation took over the system the mileage has been doubled, from 33 to 66 miles of double-track, and it now runs far into the suburbs in all directions. When the old track was laid down it was for horse haulage, and when electric traction was adopted the whole of the line was relaid. The joints were secured in the usual way, with fishplates bolted to the web and copper bonds to assist in carrying the current over them. It has now been determined, in order to make the permanent-way more solid, and to carry the return current more economically over the rails, to have the joints electrically welded, not all at once, of course, but as occasion arises.

There has been some hesitation in adopting electric welding in this country because of the unsatisfactory results of some of the numerous processes which have been tried in America. But the process of the Lorain Steel Company, of Lorain, Ohio, has been so successful, and is so ingenious, that it commended itself to the approval of the Glasgow Tramway Department. A contract was, therefore, entered into with that Company to weld not less than 2,000 joints on the Glasgow tramway lines, at so much per joint, and as many more as the Department might fix whilst the plant was in operation. On this guaranteed minimum the Lorain Steel Company sent over from America the whole of their apparatus complete, and a staff of men experienced in the working of it.

At Glasgow they built a set of four cars to contain the plant, and mounted these cars on the tramway rails. The necessary power has been supplied, gratis, from the overhead wires of the tramways. Work was done during the day on extension lines, on which new rail was laid and on which there was no interruption by car traffic. At night the plant was moved to parts of the old track which needed re-welding, but which could not be dealt with during the day without stopping the car service on one of the lines. Thus practically the welding plant was kept occupied the whole twenty-four hours, with just the time off necessary to bring the welding cars in from the suburban extensions to the city track when the latter could be got at. The illustrations we give are from photographs taken of the plant when actually at work on the Glasgow track. This is the first example, we believe, of electric welding of rail joints in Europe.

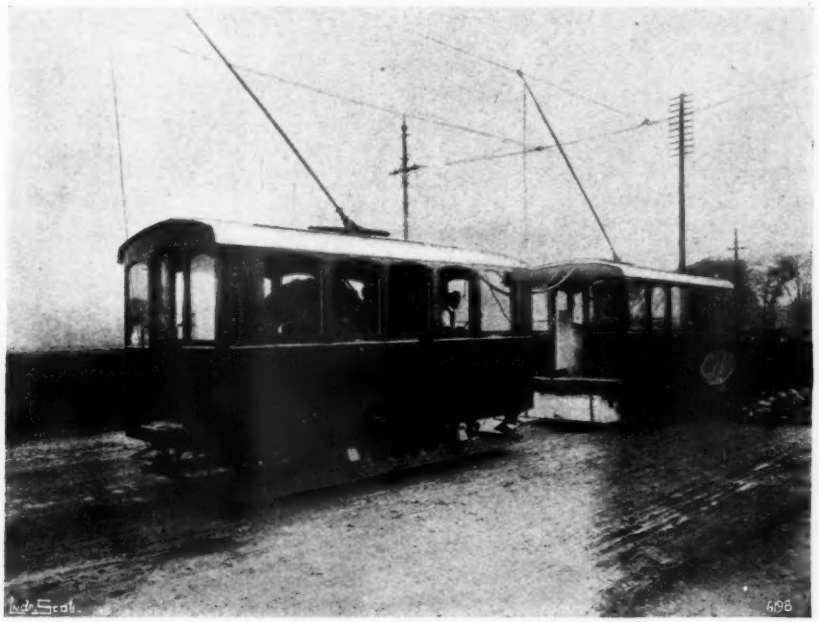
The process of welding consists of three distinct operations. The necessary machinery is mounted on special trolley cars, the running gear of which is provided with threaded axles so that the machines can be used to weld track of different gauges. New rail is welded either before or after the paving is in place, space being left at the joints to permit the entrance of the welder, but in old rail the paving is removed around the joint and the old plates and bond wires are removed. The rail ends are then brought up to the proper grade.

In the welding process the first operation

VIEW OF THE WELDER IN OPERATION.

is sand-blasting, so that all dirt, rust and foreign matter may be removed from the rails at the points where the welds are to be made, and from the bars used in making the joint. The sand-blast apparatus consists of a 10-h.p. motor driving an air-compressor, a tank for the storage of air, and a bin for holding a supply of sand. The operator, by means of a hose and nozzle, directs the blast of air carrying the sand with great force against the rail until all the foreign matter has been removed. The bars are similarly treated, and the joint is made ready for the actual operation of welding.

The apparatus for this is carried in two cars coupled together by a special form of slip coupling, which provides sufficient range of movement for the car carrying the welder to be moved from one weld to another of the three welds necessary in making a joint, without the necessity of moving the second car. The welder itself is hung from a bail on a crane extending out beyond the end of the car. This crane lowers and raises it so that the jaws of the welder can engage the sides of the rail, and shifts the welder from one side to the other to engage in turn both rails of the track. The crane is operated by friction clutches from a shaft in the car, which is kept running continuously by a 5-h.p. motor. This motor also drives a small rotary pump for circulating water through the welding transformer and the faces of the contacts, to keep them cool. After the water has passed through the welder it goes to a cooling tank on top of the car, is forced under the false bottom and made to blow in from the middle, and pass round and round until the outer circumference of the tank is reached.



VIEW OF THE WELDER CAR AND CAR CONTAINING THE ROTARY CONVERTER.

SAND-BLAST CAR AND APPARATUS AT WORK.

A false bottom is provided, and air, from a blower in the car, is forced under the false bottom and made to blow up through numerous holes. The hot water from the welder passes into the outer portion of the serpentine, and gradually finds its way to the centre, from whence it is conducted to one of the tanks in the car. In its passage along the serpentine path, the air is forced up through the water and forms an efficient method of cooling.

The welder is an alternating current-transformer, the primary winding of which consists of two coils in parallel of 44 turns each. The secondary coil is a single loop of copper of large cross-section, the terminals of which form the contacts or jaws, which engage each side of the rail and between which the weld is made. The secondary winding is so made as to entirely enclose the primary coils, which are insulated in oil. On each side of this transformer and supporting it, but insulated from it, are two

large levers, hinged together at about two-thirds the distance from the top, for transmitting the necessary pressure to the weld. These levers are connected at the top by a hydraulic jack. A hand-pump for forcing water into the jack is bolted to one of the levers. A pressure of 4,100 lbs. per sq. in. is obtained on the $3\frac{3}{8}$-in. diameter rams of the jack, the leverage on the arms increasing this so that about 37 tons pressure is developed at the weld.

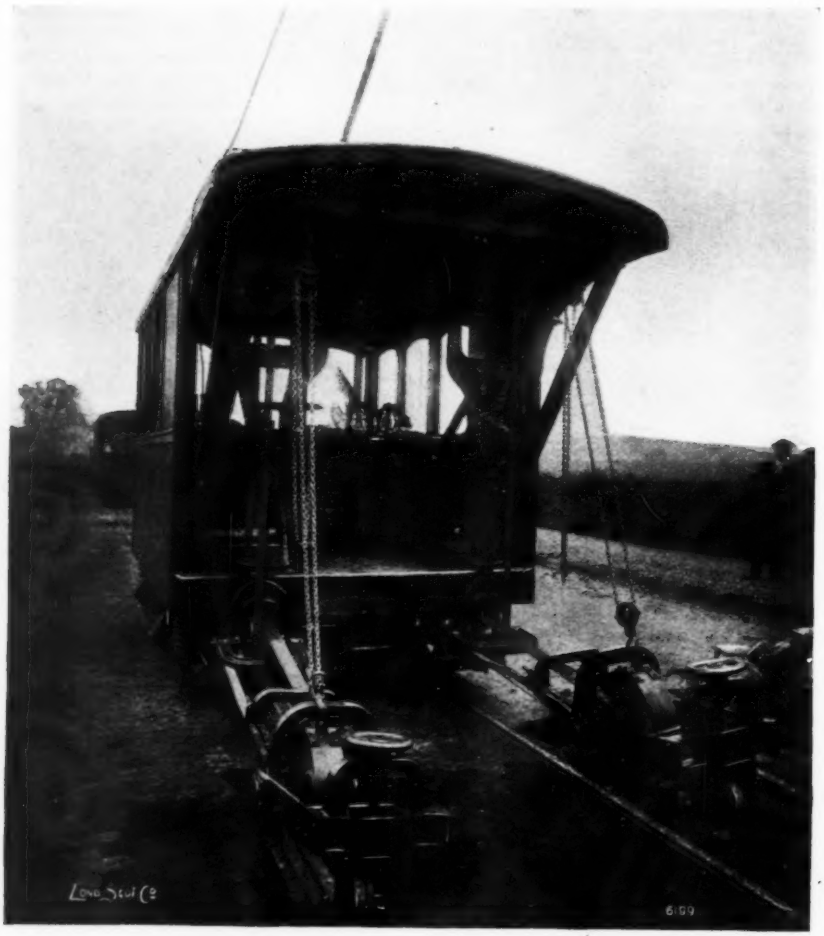
Now to describe the process of making a joint. Flat rolled steel bars are used, having at each end a boss or projection, on one side, which form the contact points between the bars and the web of the rail and confine the welded area to these sections. A flat strip of steel $\frac{1}{8}$ in. thick by 1 in. wide is placed across the middle of the bars on the same side with the bosses. The bars are supported on small blocks, and placed across the joint so that the middle strip engages the web of both rails. The middle weld is a vertical one and is made the full width of the bar. The end welds are horizontal. First of all, the welding-train of two cars is moved up to a joint, the welder is then swung into place and the jaws are made to press against the bars on each side of the rail. The current is then switched on and flows from contact to contact through the bars and the rail-web. By altering the pressure on the jaws the resistance of the several junctures is increased, and the whole is soon brought up to a welding heat. As soon as this point is reached the current is switched off and, simultaneously, the pressure is increased up to the full amount. The pressure is then loosened and the welder-car is moved back to bring the jaws opposite the extremity of the bars. The same process is again followed, except that when the final pressure has been applied it is held there, and the weld is permitted to cool under pressure until the metal has cooled sufficiently not to show any glow. The welder is then moved forward to the other end of the bar and the process repeated, after which the welder is raised and moved across the track to the other side of the car to engage the opposite joint.

By holding the pressure after the weld is made a highly tough weld is secured, but only the end welds are thus treated. As the centre weld is not subjected to any strain, it is not essential to have toughness there. The ends of the bars are welded while the bars are in an expanded state. By making the centre weld first, and not stopping to cool it under pressure, the greatest elongation of the bars is secured. After the ends are welded, and the bars cool off, they shrink, and in shrinking exert a force sufficient to bring the abutting rail-ends together, thus closing the slightest opening and leaving practically no joint at all. This is important in the manufacture of a continuous rail, for if the abutting rail-ends are not brought firmly together the metal in the head of the rail may flow into the opening between the rails, and this in time will cause a low spot in the head of the rail. As the bars are always in a state of tension the rail itself, inclosed between the bars, is necessarily in a state of compression. Any contraction of the rail between the joints will be transmitted to the end welds, and it is therefore necessary to have these welds exceedingly tough to withstand the strain. The object of the centre weld is for vertical stiffness, and to prevent any movement of the rail-ends.

The current used in welding is about seven volts and from 25,000 to 30,000 ampères. In the car coupled to the welder is carried a rotary converter for changing the direct current from the trolley to an alternating current. The current in the primary coils of the welder is 300 volts, alternating 40 cycles. The direct-current side of the rotary will take current from 350 to 600 volts from the trolley, and by means of suitable regulating apparatus the output on the alternating side, to the welder, is kept practically constant at 300 volts, without regard to the fluctuations on the line. On a line voltage of 500 about 225 ampères are required, or it takes about 125 k.w. to make a weld, the current being on about two and a half minutes to each weld.

The last operation in the process consists in grinding the head of the rail to a true surface. In welding new rails there

is little need for this, but in old track, where the rail-ends have been battered, the receiving rail is purposely welded higher than the other. The grinder is then used to grind out the inequalities on the rail-head and bring it to a true surface. The grinder consists of an emery wheel mounted on a carriage having two rollers, which are about 4 ft. apart. This carriage is let down on the rail, so that the rollers roll along the head of the rail, the emery wheel being over the uneven portion at the joint. The carriage is connected with a motor on the car by a swing frame, which enables the operator to move the emery wheel back and forward over the joint while the car remains stationary. By means of a hand-wheel the emery wheel is gradually fed down, and as it is moved



GRINDING THE FINISHED JOINT.

back and forward, grinds off the high places until the whole joint is brought to a true surface. The principle is much the same as a carpenter's plane; and with the final operation of grinding, the joint is left complete.

Carried on as a continuous process, it takes about 13 mins. to weld a joint. If the work is carried on day and night, about 80 joints in 24 hours is a fair average. The bars used are 1 by $3\frac{1}{2}$ ins., and $1\frac{1}{8}$ by 3 ins.—the length varying with the form of joint previously used. On new rail, where the ends are left blank especially for welding, the length is 18 ins. On old rail the bars must be long enough to reach beyond the old bolt and bond holes—in some cases requiring bars as long as 48 inches.

A number of advantages are claimed for electrically welded joints. Under the old system the joint is the weak part of the rail, and governs its life. Inconvenience is caused by the working loose of the joints, consequent abnormal wear and tear, disruption of the road bed, and jolting and severe bumping on the cars. The new system is expected to result in an immense saving in track maintenance, and it will conduce to the comfort of passengers in the cars when the wheels run on continuous rails. One advantage claimed for the electrically welded joint is the high conductivity obtained by the use of this process. The electric welded bars are made of low carbon steel, and are, therefore, of low resistance, and the cross section being large, the conductivity of the joints averages over 50 per cent. higher than the rail itself. No trouble is anticipated from the expansion and contraction of the rails under heat and cold. They are buried in the paving—only a small portion being exposed—and are not subject to atmospheric influences like exposed railway rail. Then it is claimed that the electrically welded joints entirely avoid decarbonising of the head of the rail by overheating. In electric welding, no more heat is developed than is actually required to fuse the metal at the point of weld, and this can be regulated to a nicety, so that the current is cut off the moment the required temperature is reached. The work is carried on so rapidly, that when a weld is being made not even the head of the rail is coloured.

In the matter of conductivity, the Lorain Steel Company supply the following results of tests made by the General Electric Company at Schenectady on joints welded by this process: Rail, 6-in. step girder, Lorain Steel Co. Bars; Rolled Steel, $1\frac{1}{8}$ in. by 3 ins. by $21\frac{1}{2}$ ins.; Cross-sectional area of rail, 43·23 sq. c.m.*

In addition to welding joints, the same Lorain apparatus is used in welding or electrically brazing copper ground cables to the rails. For this purpose a copper block about 4 ins. square and about $1\frac{1}{2}$ in. thick, with a suitable groove across one face to pass over the cable, is provided. The cable is placed against the rail web, and the copper block over the cable. The welder is then brought into position A Bessemer steel plate about $\frac{3}{8}$ in. thick is interposed between the copper block and the contact of the welder. This acts as a "heat insulator," and enables the copper block to be brought up to a proper heat for brazing. Hard spelter is used. By this means, a 500,000 c.m. cable can be attached to a rail, so that the full carrying capacity of the cable is realised, the area of union between the copper and the steel being ample to allow for the difference in carrying capacity of the two metals.

The process of electrically welding rail joints and bonds has been in experimental

* Joint No.	Resistance over Joints. Ohms.	Resistance over solid rail of equal lengths. Ohms.	Conductivity of Joint compared with solid rail.
1	59·1 c.m. ... ·00001675	59·1 c.m ... ·0000279	166·29%
2	57·0 c.m. ... ·00001625	57·0 c.m. ... ·00002636	162·20%
3	60·2 c.m. ... ·0000182	60·2 c.m. ... ·00002785	156·00%
4	56·4 c.m. ... ·0000168	56·4 c.m. ... ·00002292	136·26%

(The centimetre figures give the length of rail and joint tested.)

use since 1897. Further improvements were made in the winter of 1900, and the welding done the following season demonstrated the value of these improvements. While the breakage on all welding done had not exceeded 1 per cent., the breakage on welding done in 1901 was hardly one-tenth as great as before. Of 5,308 joints welded by the Lorain Company in Rochester, New York, in 1901, there were but six broken rails in the spring of 1902. In no case, it is claimed, has a joint broken through the bars or a weld being pulled off; nearly all breaks have occurred through old bolt or bond holes beyond the bars. By welding bars long enough to reach over the holes this source of breakage has been avoided since 1900. The experience at Rochester, New York, shows the state of perfection to which the process has now been brought. In the last three years the Lorain Steel Company have welded, at Buffalo, New York, alone, 100 mls. of track.

The Glasgow track is the first in Europe, we believe, to adopt the process, and it will be tested in that city along with a chemical process which is also about to be tried. Meanwhile, through their operations in Glasgow, the Lorain Company have received several tramway welding contracts in English towns.

Benjamin Taylor.

Modern Woodworking Machinery.

Sawing Machinery.

ALTHOUGH not many startling innovations in connection with woodworking machinery have been introduced during recent years, on the whole substantial progress has been made, more particularly in improving the design and working details of the various machines, with the object of advancing the quality and increasing the quantity of the output.

As there are probably some 200 different woodworking-machines in existence it is of course impossible to notice them all in detail; the writer therefore proposes to give a *résumé* of the chief and latest types in use, illustrated from recent photographs, which will be supplemented by a few general remarks on design, approximate speeds, etc.

Electric Driving.

Electric motors have been introduced to a moderate extent in driving woodworking machinery, both singly and in groups. As regards saw-mills and woodworking factories, unless the power is produced in the works, the problem of getting rid of the saw-dust and wood waste arises, which is a serious matter in some cases. Where electrical power is brought from a central station to compete successfully with steam and belt driving in a saw-mill, its cost should not exceed about 1½*d.* per unit. In up-to-date mills furnished with a suitable boiler and special furnace or forced draught the fuel bill is a very low one, and electric power should not cost more than, say, 1*d.* to 1½*d.* per unit to produce. Electricians generally recommend each machine to be driven by a separate motor. This may be very well for machines in isolated positions or in different floors of a building, as it does away with counter-shafts, etc., and should one motor break down it only stops one machine. On the other hand, the first cost of separate motors is very great, to say nothing of their up-keep, and the writer rather favours the running of machines in groups, although there is naturally some loss in belt driving.

With saw-mill machinery, where the load is often suddenly applied and severe, it is of the utmost importance that the right type of motor be selected and that there is a fair margin of power when working the machines at their full load, as, should the motor be pressed, it will heat and give trouble.

Each case should therefore be carefully judged on its merits, bearing in mind the old Italian proverb "*Chi va piano va sano*," which will apply to motor driving wood-working machinery as well as to other things.

We hope in these papers to be able to illustrate several machines with motors attached.

Cutting down Trees in the Forest.

Although various more or less successful attempts have been made to fell trees by means of electricity, heated platinum wires, steam-driven reciprocating saws and other mechanical means, the woodman's axe and saw are still largely in the ascendant. Given, however, a suitable site and plenty of trees that do not necessitate the constant moving of the apparatus, a steam-driven reciprocating saw may, without doubt, be made commercially successful.

Fig. 1 represents a patent steam tree-

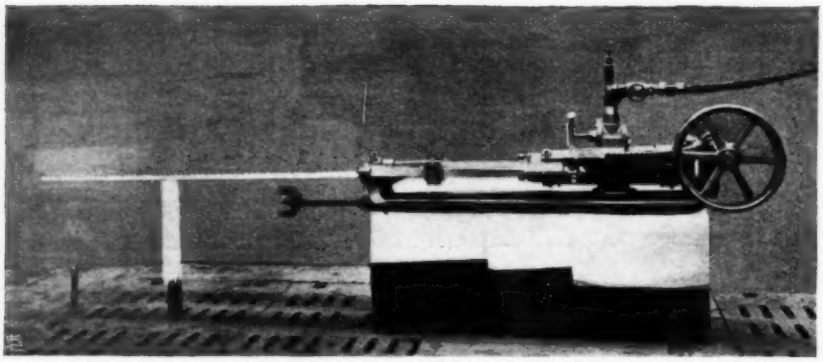


FIG. 1.—PATENT STEAM TREE-FELLER.

feller (by Messrs. A. Ransome & Co., Ltd., Newark-on-Trent). It consists, briefly, of a steam cylinder of small diameter and long stroke, the saw being fixed directly on to the end of the piston-rod, and arranged to cut during the inward stroke only, so as to avoid buckling. The cylinder is attached to a light wrought-iron frame, and is arranged to pivot on its centre by means of a hand-wheel and worm, which gears into a quadrant cast on the back of the cylinder. Suitable guides are provided for keeping the saw in a true line. When set to work, a trident-pointed bar is drawn into the tree, and the machine is attached to it by a strong screw. By a little alteration this machine can be used for cross-cutting. The weight of a machine to fell trees up to 4 ft. diameter is 4 cwt., and it requires the attendance of four men.

Cross-cutting Heavy Logs before entering the Mill.

For cross-cutting heavy logs to convenient lengths, circular or straight saws are used. In the case of circular saws, the saw is sometines arranged to work beneath the floor at the entrance of the mill, and is so constructed that it can be made to rise up through the floor and cross-cut the log as it lies on the ground across the opening. After the log is sawn the saw drops below the floor again.

Another plan is to mount a circular saw in a sliding carriage running on a cast-iron bed placed on the mill floor, the log being brought to the end of the machine from which the saw projects. These saws are usually fitted with a forward screw feed and quick return motion.

Fig. 2 illustrates a reciprocating steam cross-cut saw for logs and trees by Messrs. John McDowell & Sons, Johnstone. As will be seen from the drawing, the saw is coupled directly on to the piston-rod of a steam cylinder. The machine is self-contained and can be placed in any desired position, the only fitting required being a steam pipe from the boiler. It can be run at various speeds according to the nature and size of the timber being cut. The reciprocating parts are made light and strong, and the saw is raised and lowered by means of the hand-wheel and worm-and-quadrant motion.

Conversion of Logs.

Logs are converted into boards, scantlings, etc., by: (1) vertical log frames; (2) horizontal log frames; (3) log-band sawing machines; (4) circular saws.

Vertical Log Frames.

These represent the oldest type of sawing machines and are arranged to carry a large number of saws. They are still largely used, but have, of late, given way somewhat in favour of log-band saws

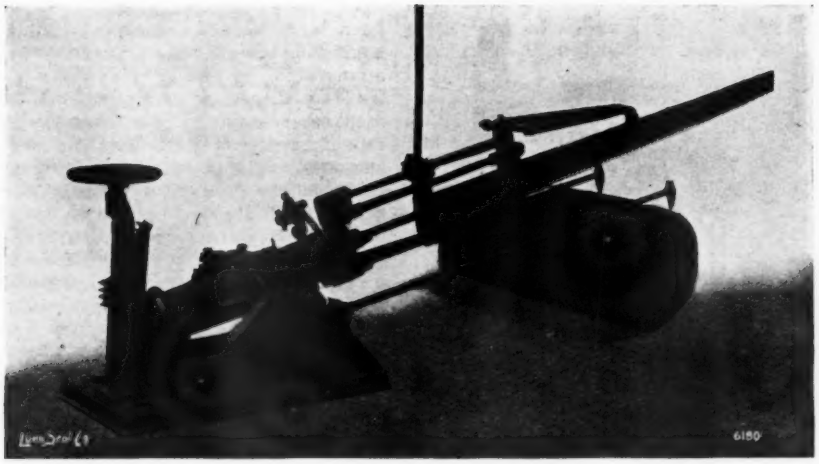


FIG. 2.—STEAM CROSS-CUT SAW.

and horizontal reciprocating-frames, more particularly for sawing hard and valuable woods. As regards construction, it is important that the main frame be of massive proportions with a considerable margin of safety; and the base of the frame should be extended to withstand the considerable vibration set up by the vertical reciprocating motion of the swing-frame carrying the saws. The crankshaft should be of steel or good wrought-iron free from seams, and cranks bent by hydraulic pressure are to be preferred to block cranks and are considerably stronger. A bearing should be placed well up to the crank on either side, and a third bearing on the outer side of the driving pulleys.

In the most recent practice, the crank-shaft is connected to the swing-frame by a pair of rods, one on either side of the frame. This secures increased strength and ease in working, the power being applied directly to where it is required, namely to where the saws are cutting. This arrangement also has the advantage of lessening the depths of the foundations necessary.

The swing frame should be of steel, and combine strength with lightness. Steel of hollow section can be recommended, but care must be taken that it has a margin of safety, and does not spring when loaded with the full complement of saws.

Ample space in the bottom of the swing frame should be allowed for the clearance of sawdust, and removable steel cross-bars fitted to the swing frame for cottering up the saws. The bearings, on which the swing frame slides, should be adjustable, and by preference made of phosphor bronze.

The side connecting-rods should be fitted with straps, cotters and phosphor-bronze bearings, and the crank-shaft bearings be of ample length, and adjustable for wear.

As regards the feed-pressure gear, the ordinary overhead weighted levers have generally been dispensed with, the pressure being applied through the medium of hand-wheels, working worms and worm-wheels, and pinions which gear into racks readily raise or lower the pressure-roller as may be desired.

For governing the rate of feed, nothing as yet has superseded the camb, or silent feed-wheel. For rapid sawing, and where the logs are fairly uniform, continuous roller-feed frames are generally employed, but for sawing uneven or crooked logs a rack-feed is to be preferred, as it is positive, and does away with the slip

FIG. 3.—VERTICAL LOG FRAME.

often found with roller-feeds when sawing difficult woods. To obviate this as far as possible a double roller-feed can be used; in this case the top and bottom feed-rollers, of which there are four, are all driven, and being all geared together a most powerful feed can be obtained.

The swing frame should be carefully counter-balanced by a suitable fly-wheel or disc. Two discs are more often employed, one being placed on either side of the machine. The cross-heads are best forged in the solid. In roller-feed log frames, where the log is carried through the saws on carriages running on the mill floor, adjustable logs are used; these should be capable of moving laterally to allow for inequalities in the log. The bearing rollers should also be arranged to rise and fall. When a rack-feed is used, a quick return motion should in all cases be fitted. The driving pulleys should be of ample diameter and width, and with very large frames requiring considerable power, increased steadiness in working and an equalised strain on the bearings may be secured by driving from inside the frame or with two belts—one on either side of the machine. Modern vertical log frames are usually arranged with a feed varying in speed from 6 ins. to 4 ft. per minute.

Speed of Vertical Log Frame Saws.

Vertical log saws—when a number of saws are cutting—are usually speeded to travel at from 450 ft. to 800 ft. per minute. Fig. 3 represents a vertical log frame with outside connecting-rods and duplex roller-feed from the designs of Messrs. Thomas Robinson & Son, Ltd., Rochdale. The log is supported on travelling carriages running on rails fixed on the mill floor, and fed through the machine by means of four rollers, two of which operate on the top of the log, and two on the bottom. All these rollers are geared, and provide a very powerful feed. They are regulated by a silent feed wheel, which receives its motion direct from the saw-frame by means of levers. The fast and loose driving pulleys are placed on the crank-shaft in the centre of the machine, which is an improvement over outside driving.

Fig. 4 shows a patent high-speed centre-driven rack-feed log frame (by Messrs. John Pickles & Son, Hebden Bridge). The chief feature of novelty claimed for this machine is in the method of driving, which is from two outside discs of large diameter. From these are connecting-rods attached to a cross-bar; from this again are two more short connecting-rods inside the frame of the machine, and arranged to take hold of the swing frame close up on each side. The usual bent

crank-shaft is thus dispensed with, and a longer stroke can be obtained, and short pins only are necessary on each side of the swing frame. The logs are fed to the saws by a travelling rack-feed carriage actuated by a variable silent feed-wheel. Screw-clips with lateral adjustment are fitted for holding the logs; also down-pressure rollers before and behind the saws.

Horizontal Log Frames.

Horizontal reciprocating log frames, carrying one or two saw-blades only, have of late come into somewhat extended use. They are particularly suited for opening out valuable logs, as they enable the operator to examine the figure of the wood as each board is removed; and, should defects be discovered, they can often be cut out, and the log converted to better advantage.

As regards construction, these frames having a horizontal reciprocating motion instead of vertical, have a greater freedom from vibration, and are much less costly as regards foundations than the ordinary vertical-frame type; and, carrying only one or two saws, can be safely run at a considerably higher speed. The frames should be made self-contained as far as possible, the bed-plate being cast in one piece; and the uprights, etc., in addition to being carefully bolted, should be steady-pinned in their places to obviate any chance of moving. The reciprocating saw frame should be light and strong, and where two blades are employed the slides can be balanced in equilibrium with advantage. Some makers arrange the saw frame to run in guides. The cross-frame should be arranged to rise and fall by hand or power, and the table fitted with adjustable screw-cramping dogs, a variable feed, and quick return motion.

The bearings in the countershaft are best arranged at an angle to withstand the pull of the connecting-rod, which should be long and light; for this purpose a steel tube is sometimes employed.

Horizontal log frame saws are usually speeded up to about 1,200 ft. per minute.

Fig. 5 represents a patent double horizontal saw-frame (by Messrs. Thomas Robinson & Son, Ltd., Rochdale).

This machine carries two saws, the working parts of which are balanced in equilibrium. Each saw works in a separate slide, and is operated by a light steel tubular connecting-rod, coupled to a two-throw crank with opposite centres, so that the motion of the one balances that of the other, thus enabling a considerably

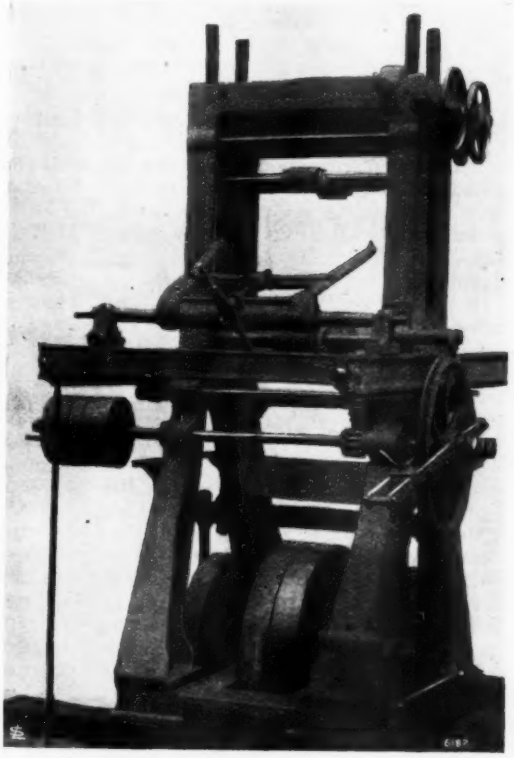


FIG. 4.—CENTRE-DRIVEN RACK-FEED LOG FRAME.

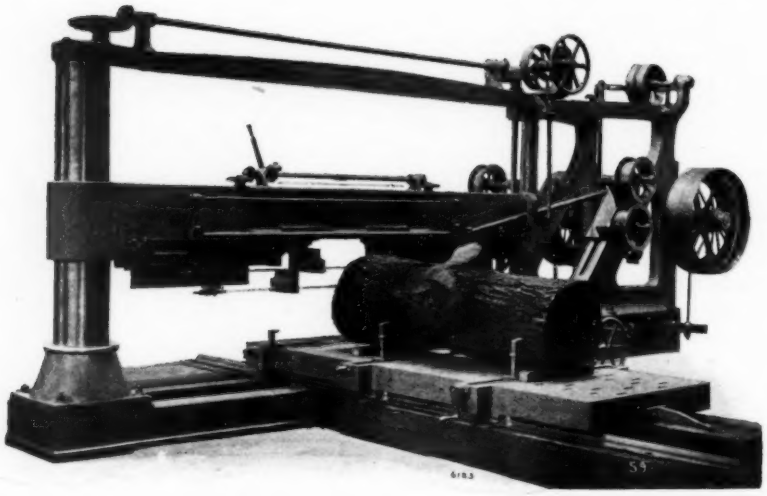


FIG. 5.—DOUBLE HORIZONTAL SAW FRAME.

higher speed to be attained without vibration. The saw frames and slides are carried on a cross-rail, which can be raised and lowered on the two vertical pillar standards, and one saw-frame having a vertical adjustment the two saws can be adjusted independently of each other for depth of cut.

Fig. 6 shows a horizontal log-sawing machine with patent balanced crank (by Messrs. John Pickles & Son, Hebden Bridge). The general details have been condensed to take up a small width of room. The cross-slide and driving gear are raised or lowered by power or hand. The saw is arranged to cut in both directions, and is carried by a specially light swing-frame actuated by a long connecting-rod from a steel crank-shaft. Special attention has been given to the balancing of the reciprocating parts, and the crank itself has balance-weights attached, and fly-wheels are also placed at each end of the crank-shaft, which enables a high rate of speed to be attained without excessive vibration.

The table runs on planed rails, and is traversed by spur, rack and pinion gear, driven by a worm and worm-wheel and five-speed core pulley to suit different rates of feed according to the kind and size of timber. A quick return motion is also fitted.

Log-Band Sawing Machines.

During recent years log-band sawing machines, constructed to work both vertically and horizontally, have come into extended use, and when properly designed, constructed and worked, possess some conspicuous advantages over other forms of log-converting machines, notably in the saving of wood, in power consumed, and the readiness with which a log can be examined as to its soundness during cutting. These machines are not, however, new, as the writer in his apprentice days, some thirty odd years ago, was concerned in the manufacture of a number of horizontal machines which were erected in various shipyards on the Thames and Clyde. They were apparently, however, in advance of the times, and the construction of log-band saws remained in abeyance for many years, and their re-introduction at a later date has been primarily due to American and French engineers.

In comparing horizontal and vertical log-band sawing machines it may be

taken for granted that, where many large logs have to be converted, the horizontal form is to be preferred, as the output is usually greater than with a vertical machine: it is more readily managed and the average work is truer. The output, of course, depends largely on the nature of the wood, the condition in which the saw and machine are kept, and the ready supply of timber, and may be anything from 5,000 to say 25,000 sup. ft. per day of 10 hrs.

A vertical band-sawing machine can be erected at a less cost than a horizontal, and gives very good results when skilfully handled.

In designing the main frame or column of log-band sawing machines strength—with rigidity in working—must be secured. In the best practice, a cored or box casting made in one piece and with an extended base is usually employed; although some American manufacturers use a wrought-iron girder column bolted on to a heavy base-plate. Whichever is used, it is important that the columns, base-plate and foundations generally, are sufficiently massive to absorb the vibration of the machine when working at its full speed. To further reduce the vibration, the saw-wheels—both of vertical and horizontal types—should be kept well down towards the base of the machine. The saw-wheel spindles should be of steel, and in all cases run in two sets of bearings—large saw-wheels running on studs are objectionable.

With the object of securing increased steadiness in working, we have seen vertical machines running with success in which the upper saw-wheel spindle ran in double bearings fixed on the top of the column, and the lower spindle in a vertical line beneath the base of the machine, with an additional pair of bearings outside the driving pulleys to withstand the pull of the belt.

Perhaps the most important feature in the construction of a band-sawing machine is the saw-wheels. These should combine strength with lightness; more particularly in the case of the upper saw-wheel in vertical machines, as, should it be too heavy, it may over-run the bottom or driving wheel, and be a fruitful cause of setting up cracks, buckling, and the consequent breakage of the saws. With the object of preventing over-running, some engineers make the lower wheel of cast iron, and about one-third heavier than the top; so that the increased momentum may prevent its speed being materially reduced when an increase of work is put on it. For heavy work, the spokes of the wheels—for which steel or wrought-iron tubes are suitable—should be "staggered"; the centres made heavier, and the rim of the wheel thickened or strengthened with wrought-iron plates or pads where the spokes are attached.

Although wrought-iron wheels are to be preferred to cast, they should be turned

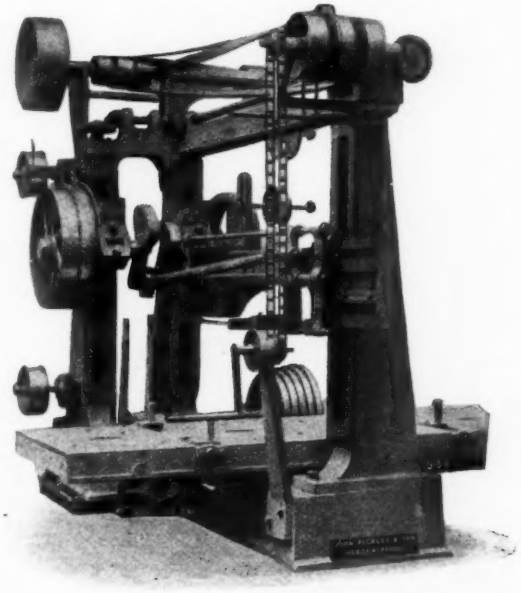


FIG. 6.—HORIZONTAL LOG-SAWING MACHINE.

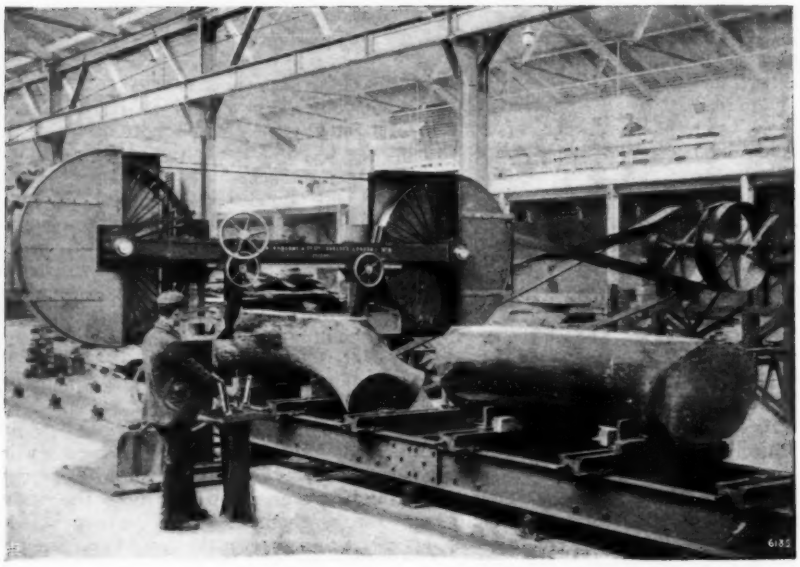


FIG. 7.—HORIZONTAL LOG BAND-SAWING MACHINE.

all over—the top wheel mounted elastically and both be in absolute balance. Should they be even slightly out of balance, the consequent centrifugal force causes a constant jumping motion which will ultimately break the finest saw-blades.

Some American makers of vertical machines construct the lower saw-wheel of greater diameter than the top, but the writer fails to see the advantage of having the arc of contact of the saw different on the two wheels. Difference of opinion also exists as to the advisability of covering the periphery of the wheels—some makers cover the wheels with wood and leather or indiarubber, and others run the saw-blade on the bare metal. It will, however, run well under both conditions.

The saw-wheels should be of large diameter—in fact, within moderation, the larger the better—as, should the arc of contact of the saw with the wheel be too acute, the blades are much more liable to be rapidly cracked and fractured. The diameter of the wheels should be in proportion to the thickness of the wood sawn. It is, however, difficult to formulate a rule on the subject, but a wheel of not less than twice the diameter of the largest log sawn can be recommended.

To secure effective working, care must be taken that the saw-blade is kept in proper tension. This is usually secured by means of a counter-balanced compound lever or powerful coach-spring. The saw should also be carefully guided and supported where it enters and leaves the cut. The timber carriage is usually a wrought-iron table running on friction-rollers or rails and operated by rope, friction-gearing, rack-and-pinion or steam "shot-gun" feed; under the ordinary conditions which obtain in this country the writer prefers the first two feeds. The carriage should be fitted with automatically adjustable sliding heads and dogs for holding the timber firmly in position, and be speeded to feed at, say, from 3 ft. to 100 ft. per minute with a quick return motion. By means of a hand lever and suitable friction-gear the traverse of the table may be readily started, stopped or reversed as may be required. In the most advanced

machines the head-blocks can be simultaneously moved by a lever and the thickness of the cut regulated to the greatest nicety by means of an indexed gauge-plate. The levers and hand-wheels controlling the stopping, starting, feeding, and adjusting the logs, should be placed so as to be readily under the control of the operator and as near together as may be.

After the log has been converted into deals, flitches, etc., they are passed on to the re-sawing machines to be converted into boards, moulding and joinery stuff, etc. The machines employed for this purpose are deal frames, band re-sawing machines, continuous-feed saw-benches, concerning which my remarks must be very brief.

Fig. 7 represents a patent horizontal log band-sawing machine (by Messrs. A. Ransome & Co., Limited, Newark-on-Trent). The main frame of the machine consists usually of two heavy, cast-iron vertical columns mounted on base-plates, and the carriage carrying the saw-wheels is raised on these automatically by means of vertical screws and suitable worm-gearing. The saw is lowered after each cut by the operator by means of a hand-wheel, its position being indicated by an index-pointer and gauge. At the same time the saw carriage being always locked by the worm-gear which raises and lowers it, it is impossible for the saw to work downwards in the cut.

The saw wheels are 5 ft. diameter, and made of wrought-steel turned all over to secure absolute balance, and the saw-blade, which has a speed of about 7,000 ft. per minute, runs on the metal rims of the wheels, which are not covered. The saw-wheel spindles are of steel, and each runs in two pairs of self-lubricating bearings, mounted in a strong horizontal casting, which can be adjusted to suit different lengths of saw, and give the proper tension to the blade without the use of levers and

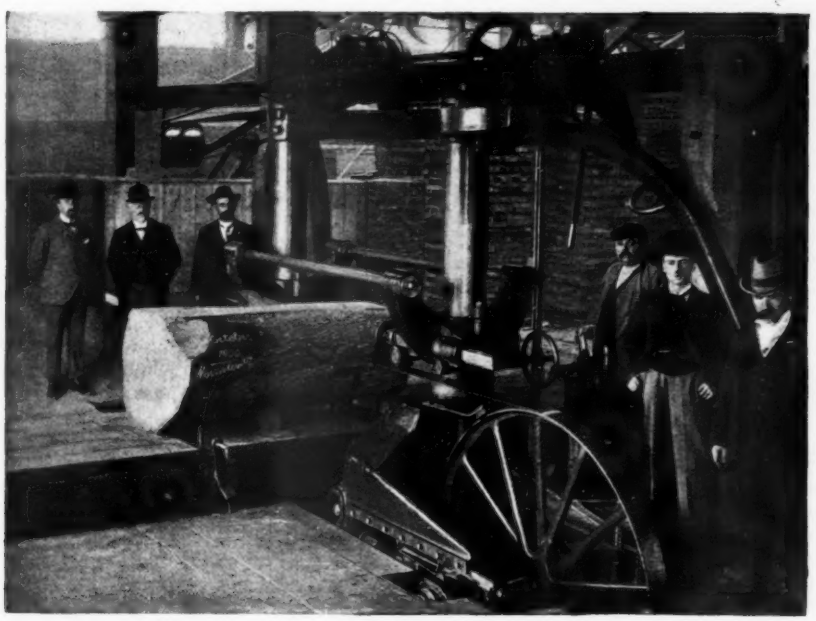


FIG. 8.—HORIZONTAL BAND MILL.

FIG. 9.—VERTICAL LOG-SAWING MACHINE.

weights or springs. The saw-blade is supported as it enters and leaves the cut by means of adjustable hard-wood guides.

The travelling table which carries the log is constructed of rolled-steel girders connected by cast-iron stretchers, and runs on a series of turned rollers mounted in carriages screwed to the floor. Each cast-iron stretcher is fitted with cast-steel dog-cramps, adjustable both horizontally and vertically. The table is traversed by double rack-and-pinion gear. The feed is operated by friction gear, and can be instantly varied by the attendant. It ranges in speed from 4 to 80 ft. per minute, with a quick return motion of 400 ft. per minute.

Fig. 8 represents a patent horizontal band mill for logs (by Messrs. Kirchner & Co., of Leipzic and London). The chief feature claimed for this machine is that the log being sawn by the top part of the blade, the working parts are kept low down, and greater rigidity is secured. As will be seen from the illustration, the saw is made to encircle the travelling carriage and log; consequently the height of the carriage above the floor is reduced. The saw-wheels are 6 ft. diameter, and made of cast-iron. The frame of the machine consists briefly of two cast-iron columns mounted on a bed-plate, and joined at the top by a cross-stay; and arrangements are made to readily adjust the saw-blade up or down, either automatically or by hand.

The saw-spindles run in double bearings with swivelling adjustments, and one movable bearing is fitted with an adjustable weighted lever arrangement to keep the saw at an even tension. Instead of using a loose pulley on the saw-wheel spindle, the makers employ an additional countershaft with a friction clutch, by which the machine can be stopped and started at will.

The travelling carriage is traversed by means of a wire rope working on a drum, which gives a steady feed; a worm-gear at the end of the carriage regulating its tension. The rope drum can be readily stopped, started, or reversed. The speed of saw is about 8,000 ft. per minute.

Fig. 9 illustrates a patent vertical log-band sawing-machine by Messrs. J. A. Fay & Egan Co., Cincinnati, U.S.A. In

this machine the top saw-wheel is mounted in double bearings and is adjustable both vertically and horizontally. The upper saw-wheel is made with steel spokes cast in the rim and "staggered;" the lower wheel is cast solid and with a web instead of spokes, and is also made adjustable vertically and horizontally. The tension of the saw blade is maintained by a lever and weight arrangement. The feed gear is attached to the base of the machine. The feed is variable and straight-faced, friction gearing is employed and is suitable for a rope or rack-and-pinion feed. Instead of these a steam feed is sometimes fitted. Adjustable guides for supporting the saw as it enters and leaves the log are provided.

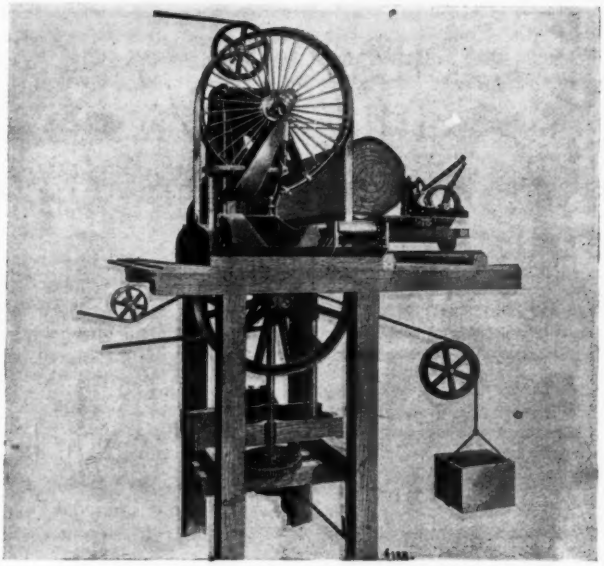


FIG. 10.—DOUBLE CUTTING TELESCOPIC BAND-SAW MILL.

The log carriage is made of yellow pine and fitted with Knight's patent dogs for holding the log in position, and all the head blocks by the movement of a single gear can be instantly set forward to take a fresh cut, or they can, if desired, be independently adjusted to suit crooked logs. The receding gear of the head blocks is automatic in its action, as is also the off-set gear, which is so arranged that the carriage and log recede from the saw the instant the carriage starts to return. The carriage is fitted with a quick return motion.

Fig. 10 represents a double-cutting telescopic band saw mill, by the Allis-Chalmers Co., Milwaukee, U.S.A. This machine possesses several novel features in its construction, the whole mechanism being arranged to rise and fall so as to bring the point where the saw leaves the top wheel as near to the top of the log as possible, the object of this being to secure a short rigid saw blade which will stand an increased amount of feed. The machine is mounted in three vertical slides, is lowered by gravity and raised by suitable screw-gearing and is partly counterbalanced.

As will be seen by the illustration, the saw is made with teeth on both its edges: this idea is not new, but it is claimed that through bringing the upper saw-wheel down to the cut and making the saw blade absolutely rigid where it enters the log, it is possible to cut in both directions of the traverse of the log carriage, consequently the output of the machines is thus largely increased. The log carriage is speeded to run at a uniform rate in both directions, and the saw cuts its own clearance with either edge when the carriage is in motion. No time is lost on removing the boards cut on the backward traverse, as the log deck is fitted with live rolls below the top of the head-blocks, and steam log loader arms are arranged with extensions which bridge over these rolls when loading logs on to the travelling carriage. To

prevent the saw being thrown by centrifugal force out of a straight line as it leaves the top saw-wheel, steadying guides are fitted. The lower guides are opened by a lever, and to facilitate the removal of saws, and are closed and locked by the reverse movement of the same lever.

M. POWIS BALE, M.I.Mech.E.

(To be continued.)

NOTES ON LOCOMOTIVE & RAILWAY ENGINEERING

W. W. M.

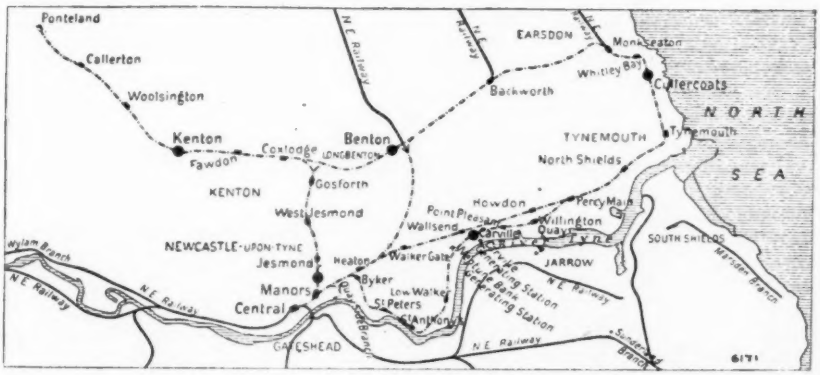
Traction Developments on the North-Eastern Railway.

THE North-Eastern Railway is justly noted for the go-ahead character of its policy, and it is therefore not surprising that we should find the Company in the front rank in its methods employed for dealing with two of the most important classes of traffic, viz. suburban or local, and the heaviest description of express passenger work.

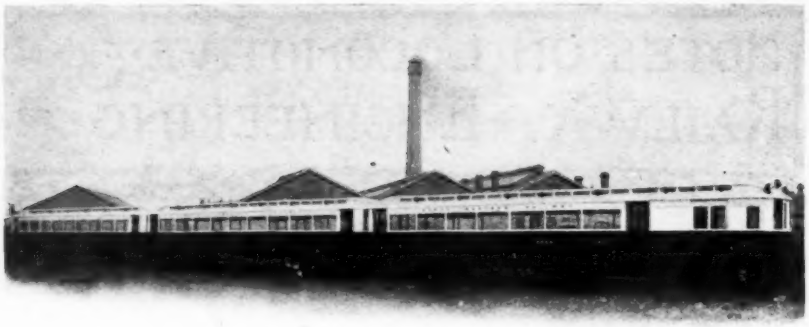
The serious nature of the competition offered by the electric tram companies in the Newcastle district has prompted the railway Company to provide opposition in the shape of electrically-operated trains, which will, when the equipment of the lines is completed, run between Newcastle and Tynemouth, and thence by a circuitous route back to Newcastle, with various loops and connections, involving in all some 40 miles of track, which is, at the present time, being worked in the ordinary way by steam locomotives. Trial trips have already been run over a section of the line between Carville Station and Percy Main, a distance of three miles. The train used is illustrated herewith, and as will be seen, it consists of three bogie vehicles of handsome external appearance. The trials demonstrated a capability on the part of the train to run at 45 miles per hour, and acceleration at the rate of 30 miles per hour within 30 secs. of starting was attained.

The cars at either end of the train are each equipped with two 150 h.p. B.T.H. motors—the bodies and trucks of the cars having been built by the Brush Electrical Engineering Co., to the designs of Mr. Wilson Worsdell, the North Eastern Railway Co.'s Chief Mechanical Engineer, to whom the writer is indebted for the photograph of the train.

The leading car contains a luggage compartment and seating accommodation for 48 first-class passengers; the trailer coach provides room for 70 third-class passengers, whilst the remaining coach will hold 58 more of the same class. The coaches are 55 feet long over headstocks, and 40 feet from centre to centre of bogies. Each motor-car is provided with four contact shoes—one at either side of each bogie truck—and these shoes are coupled together so as to ensure a



MAP OF DISTRICT TO BE SERVED WITH ELECTRIFIED LINES, NORTH-EASTERN RAILWAY.



VIEW OF ELECTRICALLY-OPERATED TRAIN FOR USE IN NEWCASTLE DISTRICT, NORTH-EASTERN RAILWAY.

continuous taking up of current at points where breaks in the collector rail occur. The Westinghouse air-brake is fitted, pressure being maintained by means of motor-driven compressors.

For working the heavy and fast passenger service between York and Edinburgh, Mr. Worsdell has designed a new class of locomotive of the 4-4-2-type with extremely large proportions. The advent of these engines was referred to in the "Notes" for August, 1903, and the first of the class was put to work in November last. The cylinders, which are placed outside the frames, are 20-in. diameter by 28-in. stroke, and the coupled wheels are 6 ft. 10 in. diameter. Other important particulars are as follows :—

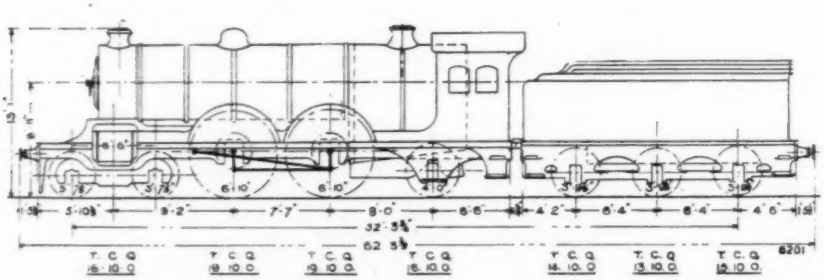
Boiler ...	length of barrel ...	15 ft. 10½ in.	
,, ...	diameter ,, (outside)	5 ft. 6 in.	
Working steam pressure ...		200 lbs. per sq. in.	
Heating surface, tubes ...	...	2275·8 sq. ft.	
,, ,,	firebox	180	,,
,, ,,	total	2455	,,
Grate area	... ...	27	,,

The tender capacities are for 5 tons of coal and 4,125 gals. of water, and the total weight of engine and tender in working order is 115 tons 10 cwt. This represents the most powerful type of four-coupled express passenger engine yet running in this country, and will no doubt be found in working to possess an ample margin of power over and above all ordinary requirements, even when the stringent conditions which obtain on the railway system in question have been taken into account.

In a future issue photographic and sectional views of this interesting design will be presented.

The Enlarged "990" Class Locomotives, Great Northern Railway.

The "Henry Oakley" or "990" class of 4-4-2 express passenger locomotives on the Great Northern Railway were among the first "Atlantic" type engines introduced upon British railways, indeed they were the first to be fitted with outside-cylinders and



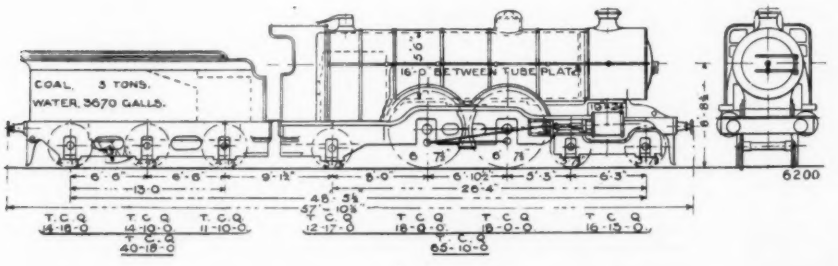
ATLANTIC 4-4-2-TYPE EXPRESS LOCOMOTIVE, NORTH-EASTERN RAILWAY.

with the second pair of coupled wheels employed as drivers. Mr. Aspinall's engines of the same type on the Lancashire and Yorkshire Railway, which preceded those of the Great Northern Railway, had inside-cylinders driving the crank axle of the first pair of coupled wheels. The "990" class have cylinders 19 ins. by 24 ins. and a total heating surface of 1,442 sq. ft.; but in No. 251, the engine illustrated herewith by longitudinal and cross sections, this figure has been increased to no less than 2,500 sq. ft. The previous 26¾ sq. ft. of grate area has likewise been augmented, and in No. 251 is 30·9 sq. ft. The cylinder and wheel diameters remain as in the earlier engines, so that it will at once be seen that the ratio between boiler and cylinder capacity has been very considerably advanced in favour of the first-named. There can be no doubt as to the advisability of this step. The tendency nowadays is to "over-cylinder" the largest locomotives, and the boiler is thus frequently unable to adequately keep up the supply of steam when the engine is working under conditions calling for the development of extreme power. There can hardly be any fear of this with No. 251, for the cylinders are, comparatively speaking, of moderate dimensions, whilst the boiler is one of the largest applied to locomotives in this country. The general construction of the engine may be followed by referring to the sectional views reproduced. The valve-gear is of the ordinary Stephenson link pattern, and as will be noticed, the valve-rod has to be cranked to clear the front-coupled axle. The weight of the expansion link and its attachments is neutralised by means of a spring in place of the usual counterweight on the reversing shaft. The engine is fitted with one exhaust steam injector and one of the Gresham and Craven pattern.

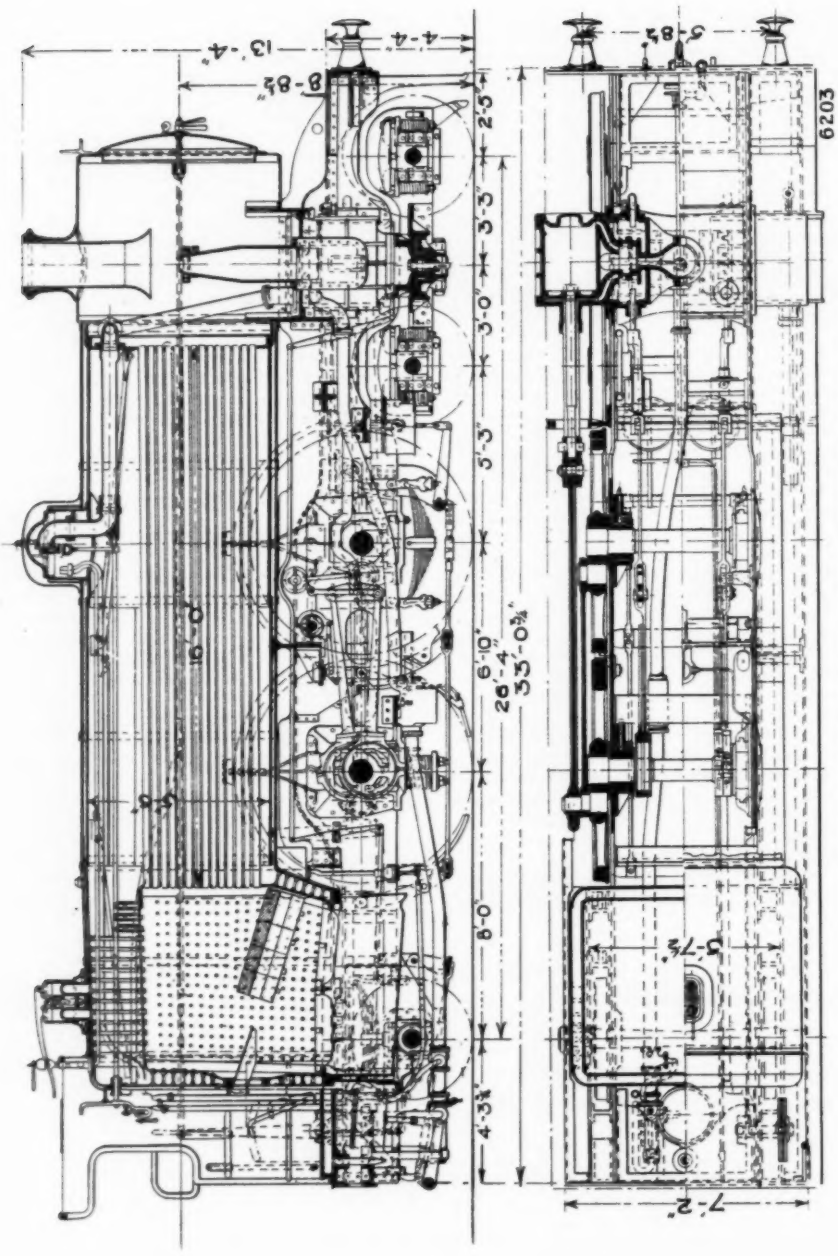
The boiler is of the telescopic pattern made up of two rings only; the material being steel ⅝ in. thickness. The diameter is 5 ft. 6 in. and the length of barrel 16 ft. There are four safety-valves enclosed within the one casing, and loaded to 175 lbs. per sq. in. The firebox is of copper $\frac{5}{16}$ in. thickness—the tube plate being ¾ in. thick. The crown stays are of the "direct" pattern; no girder roof bars being employed. The smokebox is of the extended type. A general idea of the appearance of the engine may be gathered from the diagram, and it will be seen that a six-wheeled tender of the standard pattern is provided. The capacities are 3,670 gals. of water, and 5 tons of coal, and the water pick-up apparatus is fitted. The total weight of engine and tender in working order is 106 tons 10 cwt. Trains weighing 300 tons and upwards are said to be hauled with ease, at considerable speeds, by this engine; and both it and the North Eastern 4-4-2 locomotive—also illustrated in this issue—may be depended upon to make as good a show against the performances of the Great Western Railway "de Glehn" engine, as any other type in the country.

The Berlin-Zossen High-Speed Tests.

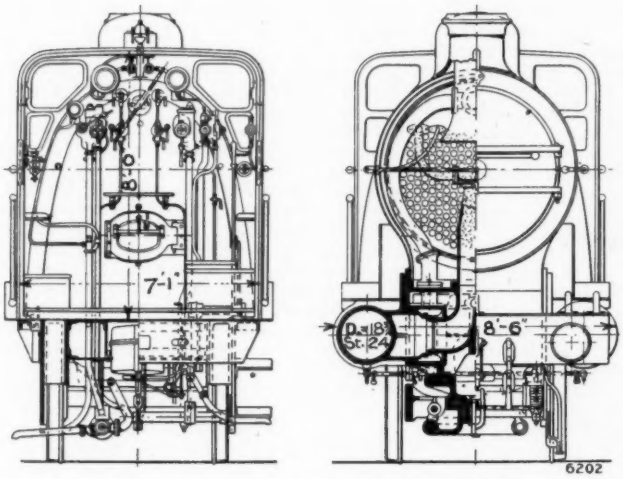
We have it upon indisputable authority that during the experiments which were carried out last year in Germany the distance of 14·3 mls. between Marienfelde and Zossen, in the vicinity of Berlin, was covered in the amazingly short time of 8 mins, which represents an average speed of 107 mls. per hr. In less than 2 mls. from the starting-point a speed of 93 mls. per hr. was reached, and maximum velocities of 125 mls. and 130 mls. per hr. were attained *en route*. These wonderful performances, as most people know, were accomplished by means of electrically propelled motor cars, specially designed and equipped for the purpose of attaining phenomenal speeds—in short, racing machines,



FOUR-WHEELS-COUPLED PASSENGER EXPRESS ENGINE, GREAT NORTHERN RAILWAY.



FOUR-WHEELS-COUPLED EXPRESS PASSENGER ENGINE, GREAT NORTHERN RAILWAY.



FOUR-WHEELS-COUPLED EXPRESS ENGINE, GREAT NORTHERN RAILWAY.

built with the one idea of getting over a given stretch of track within the least possible measure of time.

As demonstrating the practicability of exceptional speed under influences wholly favourable to its attainment, the tests were undoubtedly successful, and the highest expectations of everyone interested must have been amply realised, but, curiously enough, the results obtained have been employed by some as arguments in support of adopting electric traction on railways upon a larger scale, and throughout a wider field of operations than at present, but so far as proving the feasibility of such a course is concerned, the German trials cannot be said to have advanced matters in the least.

The attainment of high speed, by itself is by no means confined to electrically-propelled vehicles. It is certain, however, that no steam locomotive has ever covered the ground at the same rate as did the motor-cars between Marienfelde and Zossen The highest speed ever authentically recorded in favour of the former type is given as 95·1 mls. per hr. This was accomplished on the Atlantic City section of the Pennsylvania Railroad in 1902. Speeds of 90 and 91 mls. per hr. have been reached in this country by steam locomotives whilst hauling moderately heavy passenger trains, and one instance in which a rate of 96 mls. per hr. was touched has been published, but without the support of particulars.

In view of the German records, however, these are comparatively moderate figures, but in spite of this there is little reason to doubt that any person or persons —if such there be— who desire to travel at the rate of 100 mls. per hr. and upwards may do so by the aid of a steam locomotive, but it must be understood that a special racing design must be prepared, that the construction of the track must receive special attention, that there is little or no load behind the tender, and that the distance to be covered must be a comparatively short one, free from curves and gradients, and, in fact, that everything must be conducive to the attainment of the highest possible speed.

The Pennsylvania engine that covered a measured distance at the rate of 95·1 mls. per hr. was an ordinary one taken out of stock. It had four-coupled wheels only 6 ft. 8 ins. diameter, and was, in fact, never intended for any other purpose than that of hauling passenger trains at reasonable speeds varying between 55 to 65 mls. per hour on the average. No attempts have been actually made up to the present, to ascertain what is possible with the steam locomotive when every other consideration but that of mere speed is thrown to the winds. The consulting engineer to the Prussian Department of Railways, Herr Wittfeld, has, it is true, designed two high-speed locomotives which will, he believes, be capable of reaching a speed of 125 mls. per hr., but even if this proves to be the case we shall be no further ahead, as although it will demonstrate that the attainment of the required speed is practicable from the engineering standpoint, there still remains the almost certain obstacle of commercial impracticability. The travelling public demands something more than rapidity of motion nowadays. It desires comfort *en route* ; the provision of dining and sleeping accommodation, the conveyance of heavy baggage, etc., and it is safe to say that the vast majority of passengers would prefer to proceed upon their journey at the rate of from 55 to 60 mls. per hr. surrounded by the comfortable appointments of a typical modern

express train, than to be whirled through space at twice the speed under conditions which it would not be reasonable to expect could approach those which now obtain. The commercial aspect of this question is much too strong a factor in railway administration ever to be sacrificed to any consideration which would involve the most serious of outlays and the most doubtful of returns.

Private Owners' 20-Ton Railway Wagons.

Particulars of the steel framework for the class of wagon already dealt with in the "Notes" for December and January are herewith presented, together with drawings showing the construction of the same.

Quoting from the specification issued by the Railway Clearing House Committee in respect of 20-ton Private Owners' Wagons, Section 4 states :—The underframe to be of steel of approved quality, and to the general design shown on the drawing. The minimum dimensions of the principal members are as follows :—

Solebars, headstocks, diagonals, longitudinals and middle bearers, 10 ins. × 3½ ins. × ⅜-in. channel bars ; trimmers, 6 ins. × 3½ ins. × ½-in. ; end stanchions, 5 ins. × 3½ ins. × ½-in. ; curb and end rails for wagons with wood bodies, 3 ins. × 3 ins. × 16 ins. special angle bars. The whole to be so prepared that the ends have a good bearing upon the adjacent parts.

The detailed specification, setting forth particulars relating to the quality of the material employed, reads as follows :—

(2) The steel plates and bars to be of the quality of material known as mild steel, and to contain not less than 10 per cent. and not more than 15 per cent. of carbon. The ultimate tensile strain that the material will stand to be not less than 25 nor more than 30 tons per sq. in., with an elongation of not less than 20 per cent. in 8 ins.

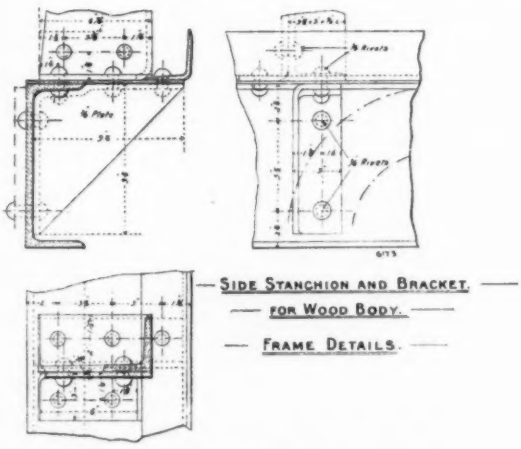
(3) All plates and bars to be made from ingots hammered on all sides, and when reheated to be rolled truly to a uniform thickness. To be perfectly clean and free from pitting, roll marks, scale dirt, overlapping, or other defects.

New Great Central Route to London.

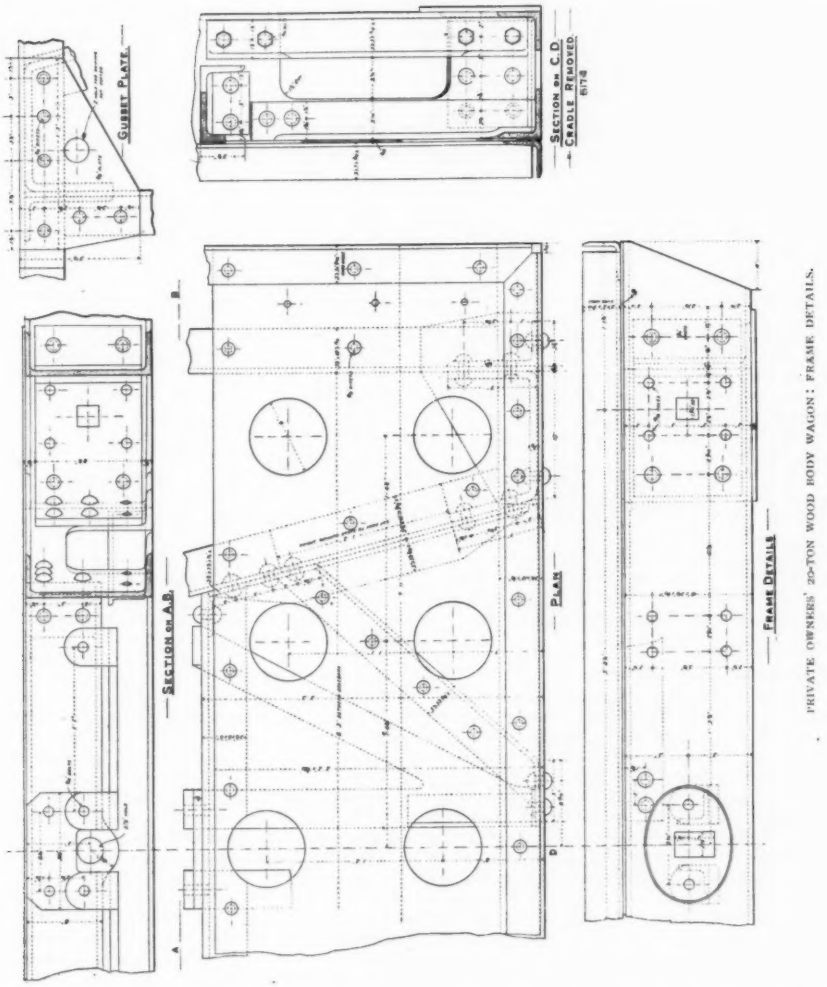
In the October "Notes" under the above heading particulars of the Great Central Railway Co.'s new line now in course of construction from Neasden to Northolt were given, and reference was made to other portions of what will, when completed, form a new route to the metropolis by linking up the existing Great Central main line north of Quainton Road with the company's present lines into Marylebone at a point near Kingsbury Neasden, thus avoiding altogether the Metropolitan Co.'s track between Quainton Road and Harrow, and thereby giving the larger company the opportunity of running their trains in and out of London without being hampered by the out-of-date methods employed by the Metropolitan authorities in the conduct of their traffic. As was stated when dealing with this matter at an earlier period, the new line joins the Great Western Co.'s railway (also undergoing preparation) between Northolt and High Wycombe, thence over the same company's existing line to Princes Risboro', and finally emerging in Great Central territory proper at the last-named point by a stretch of upwards of 12 mls. across country to Grendon Underwood, which lies about midway between Quainton Road and Calvert on the existing Great Central main line.

This contract commences at about 3⅞ mls. north of Princes Risboro', which is the junction point with the Great Western Railway Co.'s contract.

From the point of junction, about 3⅝ mls. north of same, land has been taken for four lines of way, and the works controlled by the Great Central and Great Western Joint Committee. North of this the works are being carried out solely in accordance with the Great Central Railway Co.'s types of



PRIVATE OWNERS' 20-TON WAGON.



construction, and land purchased for two lines of way.

The total length of the contract from its junction with that of the Great Western Railway, to its junction with the existing Great Central Railway main line at Grendon Underwood, is 11 mls. 37 chs.

There will be three passenger stations with goods sidings, etc., adjoining, viz.: (1) At Haddenham, about $5\frac{1}{4}$ mls. north of Princes Risboro'; (2) at Wooton Underwood, about $5\frac{3}{8}$ mls. further north; and (3) at the Bicester Road, about $1\frac{7}{8}$ mls. still further north.

The earthworks consist of about 6 mls. of cutting and $5\frac{3}{8}$ mls. of bank, the total excavation equalling about 812,000 cub. yds. including Haddenham Station Yard.

The largest cutting is 97 chs. long, having a greatest depth of 26 ft., and 228,000 cub. yds. of excavation, including 34,000 cub. yds. from Haddenham Station Yard.

The longest bank is 74 chs.; but is shallow compared with the largest bank which is

46 chs. long, with a greatest depth of 32 ft. from ground to rail level, and contains 267,000 cub. yds.

The land along which this latter bank is tipped, called the Hanksey Meadows, is at a very low level and very flat, and in times of wet weather is covered with flood-water for a length along the land of about 25 chs. It is intersected by the River Thame, naturally a sluggish stream; and at this point a brick viaduct is constructed of five arches, the span of each being 40 ft., to allow the flood-water to pass through.

In addition to the viaduct there are two flood-openings of 10 ft. each along the bank.

There are 20 bridges of types similar to those used on the Neasden to Northolt Railway; of these five are public road underbridges, five are public road overbridges, three accommodation underbridges, six accommodation overbridges, and one underbridge across the Oxford and Aylesbury tramroad.

The writer is indebted for the above particulars to Mr. A. W. H. Casson, M.Inst.C.E., who is Resident Engineer both for the Neasden - Northolt and Princes Risboro'-Grendon Underwood lengths, acting in that capacity under the direction of Mr. C. A. Rowlandson, M.Inst.C.E., the Chief Engineer to the Great Central Railway.

American v. British Locomotives.

Some very interesting comparisons relating to the above subject have recently been appearing in one of the well-known technical journals published in the United States.

Those who have the opportunity of perusing the very frequent allusions which are made to this topic in the American engineering press will no doubt have noticed that the inferences are almost invariably in favour of the home product, and that it is unusual to find much stated in favour of British practice. This attitude, it is only fair to add, is not taken up where the matter published partakes merely of a descriptive character, and in which no comparisons are drawn between the standards of this country and those of the United States; but in cases where locomotives built in both countries have been supplied to the same customer, and which are working in competition with one another, we generally find that the American engine comes out a great deal more favourably from the trials than does the British one — according to the press of the former country. In the present instance there is not much to complain of on the score of partiality. The locomotives referred to were supplied by various British and American firms to the South African railways, and it appears that during a visit paid to the States by a high official connected with the railway system in question some very marked opinions in favour of the American engines were expressed by this gentleman, who, as is only to be supposed, must be in a position to speak authoritatively upon the matter. He is quoted to have said, among other things, that the American locomotives were 20 per cent. more economical in repairs than were the British locomotives, and that one of the reasons for this was that the first-named engines had much better tyres than those sent out from this country, and further that the springs were of superior manufacture, which of course would be especially conducive, under the prevailing conditions, to lesser wearing of parts.

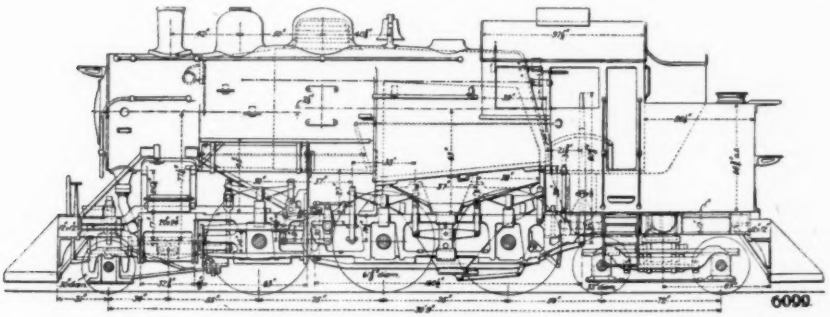
Another advantage possessed by the Transatlantic products was that they were fitted with balanced slide-valves, whereas the British engines had plain valves, and that the former greatly outlasted the latter type, which might also be expected.

It is satisfactory to learn that the English locomotives were 14 per cent. cheaper to operate in the matter of coal consumption for a given ton mileage, and this result we are accustomed to wherever British and American locomotives built for the same traffic are brought into competition with one another.

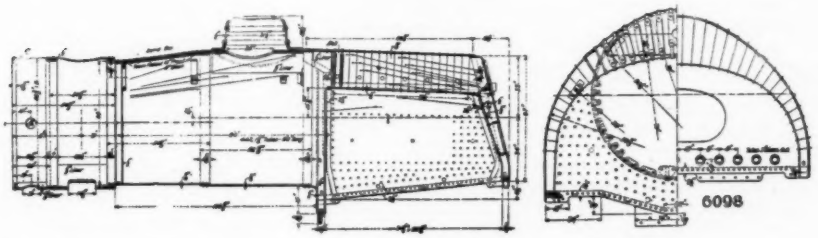
The high official already mentioned regarded the matter of fuel economy as "purely an engineering question," in which American builders can secure results quite as satisfactory as those of British builders if they could design their engines to suit existing conditions. It is to be imagined that the same might truly be said, only in an inverse ratio, of British manufacturers, regarding points in which they have failed at times in the past to make as good a show as their American and Continental competitors. Everything, in a sense, depends upon suiting the design of the locomotive (and especially its detailed mechanism) to the special conditions involved. On one point, however, there can be no doubt whatever, viz. that European locomotives are capable of exerting far greater power in proportion to their heating surface than is the case with the American production. Whether this is due to the greater amount of heat conductivity possessed by the materials employed in British boiler construction, to the lesser water consumption per horse-power hour, consequent upon the lesser cylinder clearance with relation to piston displacement of British engines, or for both and other reasons, needs to be determined. Whatever the cause, there the fact remains.

Heavy Tank Engines in America.

Towards the end of 1903, the Baldwin Locomotive Works Co. constructed six "double-ender" suburban locomotives for the Philadelphia and Reading Railroad. The design is a remarkable one, and although it is not unique so far as the United States is concerned, it would be difficult to point out where, in any other country, such an example of locomotive construction could be found.



SIX-WHEELS-COUPLED BOGIE TANK ENGINE FOR SUBURBAN TRAFFIC, PHILADELPHIA AND READING RAILROAD.



HEAVY TANK LOCOMOTIVE, PHILADELPHIA AND READING RAILROAD: LONGITUDINAL AND CROSS SECTION THROUGH BOILER.

The engines, as will be seen by the drawing, are of the 2-6-4 type, the six coupled wheels being 5 ft. 1⅝ in. diameter, and the bogie-wheels 2 ft. 11 ins. diameter, whilst the leading wheels are 2 ft. 6 ins. diameter.

The cylinders, which are placed outside the frames, are 20 ins. diameter by 24 ins. stroke, a size considered ample under existing conditions for the largest express engines in this country. The boiler is short, the tubes being only 9 ft. in length, but their number is very great—viz. 447 —and the diameter is 1¾ ins. These alone give 1,825·5 sq. ft. of heating surface. The diameter of the boiler is 5 ft. 6 ins., and the steam pressure 200 lbs. per sq. in. The fire-box is of the wide type, 7 ft. 10 ins. in length and 8 ft. 9 ins. wide, and the crown sheet is supported by radial pattern stays.

The ash-pan extends outside the frame on either side. These extensions have openings in the side, which are covered with netting, and small cleaning doors are also provided. The tank capacity is 3,000 gals. of water, and the bunker will carry 3¼ tons of coal.

The reversing-rod runs below the axles, therefore the arm of the reversing shaft is in an inverted position, and the arm itself has to be offset to avoid the lower rocker arm of the valve-gear. The rocking-shaft is placed behind the links, each of which is connected to it by a rod supported by a right-angled arm from a pin secured to the frames. The latter are of the customary American bar type.

The total heating surface is	1,981·8 sq. ft.
Grate area	68·5 ,,
Weight on coupled wheels...	60 tons
Total weight	100 ,,

Such an engine would be impracticable upon English railways, owing to the loading gauge limitations. Many of the dimensions are fully equal to those met with in locomotives of the largest description in European practice; in fact, they are, in a few particulars, in excess of what is usual on this side, even for engines engaged in hauling long-distance express passenger trains and other main line traffic requiring powerful locomotives.

The P. and R. locomotives are employed on suburban trains comprised of six cars, and as there are ten stops in the first six miles, it is necessary that quick acceleration should be provided for. The section of the line worked over abounds in heavy gradients and sharp curves. Four coupled bogie engines with tenders were formerly used on this traffic.

CHAS. S. LAKE.

MARINE ENGINEERING & SHIPBUILDING NOTES

North-East Coast Notes.

THE termination of 1903 has happily seen the amicable settlement of the wages question in the north-east shipbuilding yards. The reductions came into force on the first day of the New Year. Further notices have now been posted in the engineering establishments for reductions to come into force about the beginning of March. Such a course is only possible in the face of the general depression in engineering and shipbuilding industries throughout the country. Unfortunately, there seems to be an impression abroad that the proposed reduction will meet with opposition by the members of the Amalgamated Society of Engineers.

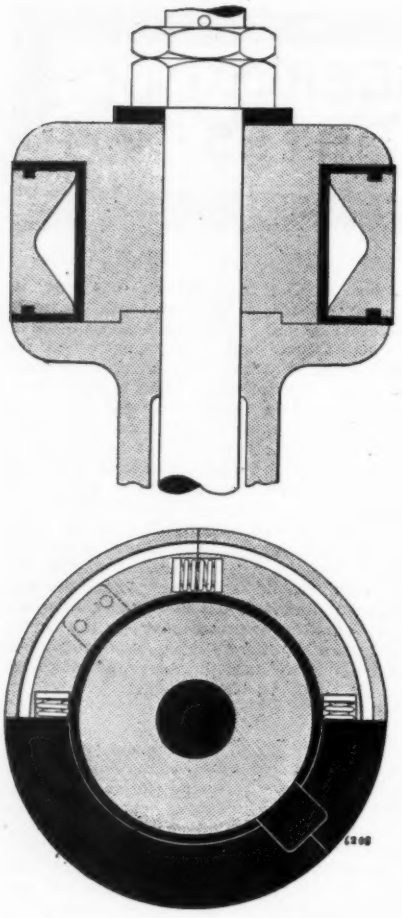
For the past two years there has been a steady decline in the tonnage output of the United Kingdom. The annual returns, published at the end of last year, show that the output has diminished approximately at the rate of 200,000 tons per annum—the actual returns being :—

1901	...	...	1,802,200 tons.
1902	...	...	1,614,000 ,,
1903	...	...	1,403,000 ,,

The decline has been fairly general, and prospects are the reverse of hopeful. Demand for new tonnage is exceedingly scarce, and competition correspondingly keen. The present slackness is largely due to the enormous production during the recent prosperous times. Shipowners, tempted by the remunerative freights, added largely to their fleets, and are now realising the price which must be paid for such additions. The few inquiries which are now in the markets, are for the most part merely on account of the low prices at which new vessels may be obtained.

The most interesting order recently booked is that of an American Lake steamer capable of carrying between 1,500 and 2,000 passengers, which was secured by Messrs. Hawthorne, Leslie & Co., of Hebburn-on-Tyne, in December, to be engined with Parson's Steam Turbines. The machinery will be of the usual three-shaft arrangement which has been adopted in the Clyde and cross-channel steamers. A turbine is fitted to each shaft. The h.p. turbine is placed in the middle of the ship, and the two l.p. turbines one on each side. On each shaft there is one propeller. A reversing turbine is fitted inside the exhaust casing of each low-pressure cylinder. In going ahead, the steam from the boilers is admitted through a suitable regulating valve to the h.p. turbine, and after expanding about five-fold, it then passes to each of the l.p. turbines, and is again expanded in them about 25-fold, and passes to the condenser. It is a matter for gratification on the north-east coast that the Tyne will have the honour of building the first turbine-propelled vessel on the Great American Lakes.

The question of an efficient system of technical education of young shipbuilders and engineers is receiving the closest attention of north-east coast employers. An educational committee—formed of many of the most prominent employers in the district, connected with the North-east Coast Institute of Engineers and Shipbuilders—has issued a report dealing with the matter in a most comprehensive manner. Briefly, there are two sections under which youths will be classified. Those under the first section will be termed "pupils," and are those who enter works with a view to attaining official positions. The pupilage will extend over a period of six years—one half of which will be spent at college. The second section will include those who enter works with a view to becoming expert at some particular handicraft, and do not attend a systematic day course at college, and who will be called upon to serve five years' apprenticeships. As an incentive to both sections to take full advantage of the opportunities thus opened out to them, increased pay—depending



DETAILS OF AIREY'S PACKING RING.

in amount on the degree of success attained —will be allotted to those who acquit themselves to the satisfaction of the college authorities and employers. The scheme, which deals with every requirement so far as is possible, will be dealt with hereafter at greater length.

* *

Any fitting which by its adoption is the cause of saving in power and secures greater economy in land or marine engines, should receive every welcome at the hands of those who have to deal with the power question. We have received, recently, a sketch of a packing ring, patented by Mr. James Airey, of West Hartlepool, which has been extensively adopted in land and marine engines. The diagram clearly shows the features of the ring. Practical experience has proved its qualities. One shipbuilding company on the north-east coast have written saying that they have fitted the Airey packing-ring to their main engines, which are of the Robey type running at 250 revs.—driving the shipyard machinery which has been working for upwards of three years without showing any perceptible signs of wear, and have required very little readjustment. A chief engineer of a merchant steamer states that since fitting these rings, the result has been an increase of $\frac{3}{4}$ of a knot in speed, and a reduction in coal consumption of $1\frac{1}{4}$ tons per day.

* *

The application of oil as a medium for raising steam on board ship has engaged the attention of the Wallsend Shipway and Engineering Co. for many years past. Experiments have been conducted by them, and a great number of vessels have been fitted with oil-burning apparatus with signal success.

Until facilities for obtaining supplies at different ports were provided by the well-known Shell Transport and Trading Co., of which Sir Marcus Samuel is the head, the great objections were that known oil-fields were few, and confined to more or less restricted areas, and the difficulties and cost of transport were excessive.

The company, recognising the great possibilities of oil as a fuel for marine and other purposes, have established stations for oil storage and supply all over the world and have constructed a large number of steamers capable of carrying oil in bulk, many of which have been fitted by the Wallsend Co. for this class of fuel.

The advantages attendant to the use of oil-fuel certainly justify the belief that at no very distant date it will be regarded as a prime agent for raising steam on board ships

Various methods are adopted for injecting oil into the furnaces by means of a pump or with steam jets, the result being that uniformity of steaming is obtained owing to the temperature in the furnaces being constant, which is impossible with the use of coals when the furnace-doors must be opened constantly to admit stoking, allowing an inrush of cold air and causing rapid changes of temperature, thus impairing the combustion efficiency of the furnaces. Indeed, it is a common occurrence for ships to complete a voyage

without the furnace-doors having once been opened. The labour entailed is much less and thus reduces the personnel and consequent expenses of the stoke-hold: in addition, owing to the oil being injected by means of an independent agent, combustion is independent of draughts from vents, etc.

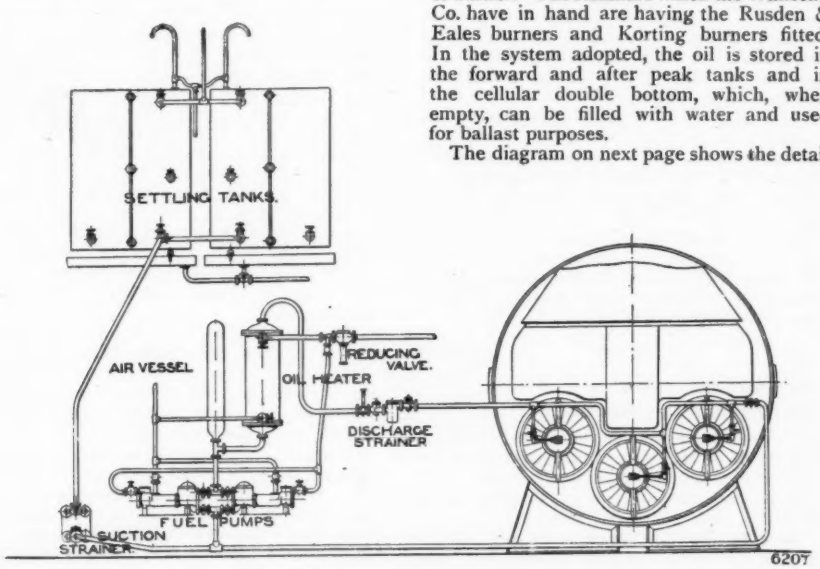
The objectionable feature of coaling, in all steamers, is dispensed with, whilst the possibilities of obtaining supplies at sea from another steamer are greatly enhanced, which is an important factor—particularly in the case of warships. The oil-tanks can be replenished in port in much less time and with much less cost than taking in bunker coal.

The initial cost of oil is, in many instances, greater than that of coal; but this varies with the part of the world in which supplies have to be obtained. The Shell Transport Co. are supplying steamers in London with oil at 40*s.* per ton; whilst in Eastern ports it ranges down to 25*s.* per ton, but against this must be set the greater evaporative efficiency and more compact stowage. Under ordinary service conditions, it has been found that oil can evaporate in conjunction with forced draught, 15 lbs. of water per lb. of fuel consumed, as against 9 lbs. with the best marine boiler using coal. Stating the case generally, under similar conditions a steamer of 1,400 i.h.p. burning 24 tons of coal per day—fitted with oil burning apparatus—has reduced the consumption to 13 tons of oil per day. The stowage varies with different oils: Texas oil occupies 39 cub. ft. per ton, while Borneo crude oil occupies 37·4 cub. ft. as against 42 to 46 cub. ft. of coal.

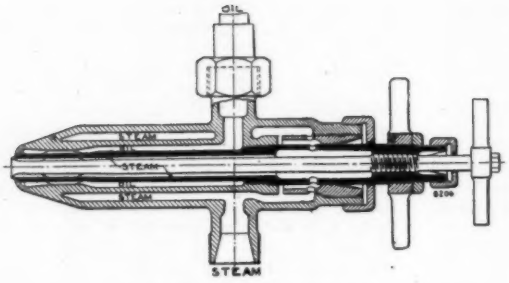
The system which the Wallsend Co. are at present fitting on a number of steamers is on the Flannery Boyd principle. The feature of this system is the separation of oil from any water with which it may have become mixed in the ballast tanks; the ballast, and forward and after peak tanks being usually utilised for storage of the fuel. It is necessary to get rid of the water from the oil, as in passing into the furnaces it may cause dangerous explosions. In order to attain this end, two or more settling tanks are used, in which the oil is allowed to remain for a sufficient length of time to allow the water to be deposited To facilitate this, a heating system has been introduced into the tanks, as it has been found that, by heating, the water is more quickly deposited. Two or more tanks must be used, so that, while the water is being deposited in one tank, the oil which has been already deposited in the other may be fed by suitable apparatus to the burner.

This system may be applied to any kind of burner. The steamers which the Wallsend Co. have in hand are having the Rusden & Eales burners and Korting burners fitted. In the system adopted, the oil is stored in the forward and after peak tanks and in the cellular double bottom, which, when empty, can be filled with water and used for ballast purposes.

The diagram on next page shows the detail



DETAILS OF OIL-BURNING ARRANGEMENT, KORTING SYSTEM



DETAILS OF RUSDEN AND EALES' BURNER.

of the Rusden & Eales burner. With this apparatus the oil is sprayed into the furnace by means of a steam jet. These burners are necessitated by the fact that complete combustion can only be obtained by causing the oil to enter the furnace in a finely divided state; hence it is admitted into the furnace pulverised into spray by means of the steam jet, where under ordinary conditions of care, perfect combustion takes place—which is demonstrated by the absence of smoke at the funnels. With perfect combustion, no deposit is left in the furnaces or uptakes, thus saving the frequent cleaning so indispensable with the use of coal. Should it be desired to burn coal and oil at different periods, it is possible to change the system within the space of half-an-hour.

The Korting system of spraying oil as adapted to the Flannery Boyd principle is also illustrated. The fuel is simply sprayed direct into the furnace by means of a pump, after having been carefully filtered and heated to a temperature depending upon the amount of oil to be burned. Since with this burner no steam jet is required for pulverising the oil, the evaporative plant necessary in the case of the Rusden & Eales burner is dispensed with. (H. B. D.)

Shipbuilding and Engineering in Scotland.

THE close of the year enables a review of the work of the past twelve months to be made; and though results are better than was at one time anticipated, they yet mark a falling off as compared with 1902.

During the past year shipyards on the Clyde, the Forth, the Tay, and the Dee have turned out 362 vessels, having an aggregate tonnage of 484,853 tons, with 497,396 i.h.p. the corresponding figures for 1902 being 404 vessels, of 566,553 tons, and 510,808 i.h.p.

The year's work on the Clyde (277 vessels) includes the usual miscellaneous series, commencing with 104 trading steamers, 5 warships, 42 dredgers, and 38 river steamers. Tugs, launches, and ferries, with liners and sailing ships make up the above-named total.

The most important launches of 1903 have been the *Commonwealth*, at Fairfield, and the *Hindustan*, at Clydebank.

Special interest attaches to two turbine steamers launched by Messrs. Denny, of Dumbarton, a class of vessel which at no distant date will undoubtedly hold the field. Indeed, it is not too much to say that a new era is dawning in shipbuilding, and that the turbine steamer will ere long completely revolutionise the industry.

The construction during the past year of two floating docks marks the inception, it is understood, of a new industry on the Clyde, and if submarines had only come north the Scottish output would have included practically every class of vessel.

Turning now to the future, the fact cannot be gainsaid that practical men hold views the reverse of sanguine for 1904. In this connection, however, it may be noted that the commencement of the year now closed was viewed with considerable misgivings, which, though in part realised, happily fell considerably short of the fears at one time entertained, and though beyond all question 1904 will prove itself a lean year, there is no cause for the almost despondent gloom entertained in some quarters.

Order books on the Clyde are undoubtedly light; many berths are empty, or about to be depleted, with no replace orders to take their place, and men are being paid off in large numbers.

On the other hand, it is fully recognised that the men as a body are behaving admirably, and submit to reductions of wages, entirely grasping the position, so co-operating loyally with the masters in difficulties of which both sides are cognisant.

Steel, too, is cheaper than ever, and seems likely to remain so for some time; so that with willing workers and cheap material it may be hoped that, as the country emerges from the exhaustion of the late war, the shipbuilding industry may ere long find itself on the upward curve of prosperity.

The Clyde Trustees are once more busy with schemes for adding to their already extensive accommodation, and their two Bills promoted in Parliament abundantly evidence the fact that in the opinion of this shrewd and farseeing body at least the old country is by no means played out. To be ready for the coming boom has always been the policy of this body, and the prosperous condition of its finances bears practical testimony to the soundness of the views followed. Under the first Bill powers are sought to carry out much widening at Merklands, Erskine, and elsewhere; under the second Bill the construction of a large dock at Shieldhall and Shields is desired.

Messrs. William Beardmore's new shipyard at Dalmuir proceeds apace, and the monster electric crane, 150 ft. in height, capable of dealing with 200 tons, forms a very striking feature in the landscape.

Another important firm also persuaded that good times are not far distant—Messrs. John Shearer & Sons, Ltd.—are also pushing on with a new shipyard, which, together with a graving dock and slipway, will occupy about 25 acres between Scotstoun and Yoker.

An event of the past month has been the launch of the battleship *Hindustan* by the Duchess of Connaught from the yard of Messrs. John Brown & Co., Ltd., Clydebank.

The *Hindustan* is one of the vessels of the *King Edward VII.* class, and was laid down on October 25th, 1902, so that only some fourteen months have been occupied in her construction. The vessel and her consorts are the heaviest battleships of the Royal Navy. The leading dimensions are: displacement, 16,350 tons, with a draught of 26 ft. 9 ins.; length, 425 ft.; and beam, 78 ft. The engines are 18,000 i.h.p., and give a speed of 18½ knots per hour. The vessel is heavily armoured. The depth of the broadside belt is 22 ft., having a thickness at the water-line of 9 ins. to 7 ins. at the upper deck. The barbettes have a thickness of 12 ins. where exposed, and of 6 ins. below.

A feature of the vessel is the increased thickness of the gun shields for the 12-in. guns over that given in former cases.

The armament consists of four 12-in. guns in pairs, placed respectively in the fore and aft barbettes; and of four 9·2-in. guns, each in separate barbettes. There are additionally ten 6-in. guns, fourteen 12-pounders, fourteen 3-pounders, two machine guns, and four submerged broadside torpedo tubes, and one after submerged tube.

A feature of the *Hindustan*, and of all vessels of her class, is that the 6-in. guns are all enclosed in a battery on the main deck with traverses; a system not hitherto adopted in the Royal Navy.

Watertight compartments divide the machinery space into two divisions for the engines, and into four divisions for the boilers. The coal capacity is no less than 2,000 tons.

There are two main engines, each having one high-pressure cylinder, one intermediate cylinder, and two low-pressure cylinders. The propellers have four blades, the bosses, cones, and guards being also of manganese bronze.

Four condensers are provided, two to each engine. The boilers are eighteen in number, of the Babcock & Wilcox water-tube type, together with three single-ended return-tube boilers. The working pressure is 210 lbs. per sq. in. The water-tube boilers will supply about 14,400 i.h.p. and the cylindrical boilers about 3,600 i.h.p. The launching weight of the *Hindustan* exceeded 8,000 tons.

(E. G. C.)

REVIEWS OF BOOKS.

Elements of Electro-Chemistry, treated experimentally. By Dr. Robert Lüpke, Headmaster of the Municipal Dorothea Realgymnasium, and Lecturer in the Imperial School of Posts and Telegraphs, Berlin. Second English Edition, revised and augmented from the 4th German edition by M. M. Pattison Muir, M.A., Fellow and Lecturer of Gonville and Caius College, Cambridge. Demy 8vo, 7s. 6d. (London: H. Grevel & Co. 1903.)

The science of electro-chemistry has been very largely developed within comparatively recent years, and a vast amount of litearture has been published on the subject. At first one had to refer to the pages of technical journals and of the proceedings of learned societies to find out the exact state of the science, but more recently the work of collection has been undertaken by several independent writers, mostly on the Continent, who have produced excellent books on the subject. Some of the leading experimenters on the subject have also published their work in book form. But for many readers these books, excellent as they are, would not form a good introduction to electro-chemistry. The theories with which they deal are very complex, and introduce ideas with which the student of elementary electricity is not very familiar, so that he gets lost before he has gone very far into the subject. But if he were to attend a course of experimental lectures on electro-chemistry, and had each step in theory deduced from the result of some experiment performed before him, he would soon find himself at home in the subject; with closer acquaintance the strangeness of the ideas and conceptions would disappear, and progress would become easy and rapid. In the volume before us, the author has tried to follow out this line of treatment as far as is possible in a book, and he has succeeded in giving an interesting and clear introduction to the subject, which may with advantage be studied by readers before tackling more profound works, and which will give them much information on the modern theories of electro-chemistry.

In this work no attempt is made to treat the applications of theory to practice in the technical electro-chemical industries. Incidentally, in discussing certain experiments reference is made to the practical applications of these experiments in electro-metallurgy and so on, but apart from these side references the author has confined himself to the purely scientific aspects of electro-chemistry. Even the practical man, however, if he is not to work blindly, and especially if he desires to be in a position to make improvements on the practice as he finds it, must pay attention to theoretical considerations, and we believe that he will find the treatment adopted in these pages more congenial to him than that usually adopted.

The translation has been well done by Mr. Pattison Muir, who has in one or two places added a word or a phrase (within square brackets) to make the author's meaning more clear. The illustrations are numerous, and consist mostly of simple diagrams of the apparatus used in experiments described. One or two misprints have been passed over in the text, but none of a serious nature have been noticed by us.

It is evident that Dr. Lüpke's book has been welcomed in Germany, as four editions have now appeared, and we believe that this second edition in the English language will find many readers and will prove to be a useful text-book to many students of electro-chemistry.

Elementary Treatise on Electricity and Magnetism. By G. Carey Foster, F.R.S., Fellow of and Emeritus Professor of Physics in University College, London, and Alfred W. Porter, B.Sc., Fellow of and Assistant-Professor of Physics in University College, London. Founded

on Joubert's *Traité Élémentaire d'Electricité.* Second Edition. 1903. (London: Longmans, Green, & Co. 10s. 6d. net.)

Some seven years have passed since Professor Carey Foster and the late Dr. E. Atkinson published their elementary text-book on electricity and magnetism, based upon the well-known French text-book by M. Joubert Their work was recognised to be an excellent addition to technical literature, and from its first appearance it has held a place among the best text-books on the subjects with which it deals. It was much more than a translation of the French work on which it is founded, for the authors, while following the general scheme of M. Joubert's volume, took an independent line in their exposition of the fundamental principles, preferring to introduce at the outset, as they stated in their preface, "that view of the nature of electrical phenomena which was originated by Faraday and developed by Maxwell in his classical treatise." It seems to be beyond dispute, with our present knowledge of electricity, that the student gains much by being made familiar from his first entrance upon the study of this subject, with the conception of stresses in the ether, and to look to the ether as the seat of electric energy. By adopting this line of treatment the authors made their work thoroughly in accordance with modern views, and in every other respect the changes they made on M. Joubert's text-book were such as added to the usefulness of the work and helped to make it more attractive. Now the time has come for the issue of a second edition, and after having examined it closely, and having tested it, we feel sure that it will meet with greater success than ever, and will be much used by students of the subject. In its contents it departs still more from the original French form, and to that extent becomes still more an original work. A change in the authorship has become necessary by the death of Dr. Atkinson, whose place has been taken by Mr. Alfred W. Porter, Assistant-Professor of Physics in University College, London. In him, if we may judge by results, Professor Carey Foster has found an able collaborator.

The changes made in the present edition are mostly in the form of additions, but in one or two places the text has been re-written in order to introduce a better method of exposition. In the part which deals with electrostatics, a section has been added on electric images for the discussion of the mutual electric influence of spherical conductors. This involves the use of mathematics, and throughout the volume the authors have not hesitated to adopt mathematical treatment where that seems necessary or preferable. This may be a difficulty to non-mathematical readers, but without mathematics the discussion of theory must be seriously limited. In the chapter on the "Chemical Action of the Current," a section has been inserted to explain Kohlrausch's calculation of the velocities of ions from the conductivity of the electrolyte. The preceding section which deals with Grotthus's hypothesis has been enlarged to introduce the idea of ionisation, now so popular among workers in electro-chemistry, and the authors have given a brief account of the theories developed from the work of Hittorf, Arrhenius, Ostwald, and others.

When we come to the chapters on magnetism we find that a complete change has been made in the method of developing the laws of that subject. In the former edition the usual method was followed of beginning with the idea of magnetic poles, and using Coulomb's law of the inverse square of the distance in the quantitative analysis of magnetic action; but in the present volume the conception of magnetic poles and pole-strength is lightly passed over, and taking magnetic moment, which may be exactly determined experimentally, as the basis of quantitative discussion of magnetic phenomena, the authors develop the analysis from Gauss's law of the inverse cube of the distance. In the chapters on "Electro-Magnetism" various changes have been made and many parts rearranged. The number of illustrations of the application of theory to practice in electro-dynamic machinery has been increased, and in some respects the theoretical discussion has been amplified and improved. As an example we may cite the section, now inserted, on rotating fields, in which the authors give a mathematical analysis of the principles underlying the action of the induction motor. This is a subject which frequently offers difficulty to the student, and is often left unexplained, or not satisfactorily explained, in text-books, and the fact that the authors have dealt with it here in an elementary text-book, is evidence in itself of the thoroughness with which they have done their work, and of its comprehensive character.

We might go on giving instances of additions and changes in this edition, but enough has been said to show that no effort has been spared to make the book as complete as possible in its treatment of the principles of electricity and magnetism. The recent developments in the field of research in which Professor J. J. Thomson and his

students in the Cavendish Laboratory have done such brilliant work, receive brief notice in a new chapter added at the end of the volume. In future editions we have no doubt this chapter will be much enlarged, but in its present form it should serve as a good introduction to this most interesting, even if speculative, branch of physics, and should lead students to enquire further into the subject. The most recent investigations on radium are not noticed; some of them were probably not yet published when this chapter went to press, but cathode rays, Röntgen rays, Becquerel rays, and canal rays are all passed in review, and the work on nuclei, developed mostly by C. T. R. Wilson in this country, and by Elster and Geitel in Germany, also receives attention.

The appearance of the volume is somewhat changed, as it appears now in octavo size instead of crown octavo. The type remains as before, with the exception of headlines on pages, which are now in large capitals. In every way the volume has been improved, and while congratulating authors and publishers, we cordially recommend it to the attention of students.

Experiments with Rapid-Cutting Steel Tools.

(Continued from page 42.)

Results of the trials made to test endurance of the new steels upon a lengthened run, with an uniform shape of tool.

The objects of this series of trials was to ascertain whether lengthened runs could be made with the new steels at speeds approaching those adopted for the shorter runs of the earlier trials without serious deterioration of the cutting edge. They were intended to be of two hours' duration upon both soft steel and medium cast-iron. The tools were chosen from those already used—one from those supplied by each maker; were reforged and tempered in the School to their instructions, and ground to a shape common to all. The shape and angles adopted are shown in Fig. 10. Trials were also made with ordinary Mushet and ordinary water hardened steel tools for comparison with the above.

The results of all these trials are given in Tables XX. and XXI.

These trials show that a speed of 90 ft. per min. may be maintained for a considerable period, with a $\frac{3}{16}$in. cut by $\frac{1}{16}$in. traverse, upon material similar to the fluid-compressed soft steel operated upon, as only 3 out of 7 tools failed to fulfil the expectations of the Committee. They also show that the new steels will cut more than twice as fast as ordinary Mushet steel, and more than four times as fast as ordinary water-hardened steel.

With regard to the endurance trials on medium cast-iron, three out of the thirteen tools tried ran for an hour, or longer, at 34 ft. per min. with a $\frac{3}{16}$in. by $\frac{1}{16}$in. cut; but no tool completed the intended run of two hours' duration.

An ordinary Mushet tool ran for an hour on this material at a speed of $19\frac{1}{2}$ ft. per min., whilst ordinary water-hardened tools failed in from 4 to 9 mins. at 12 ft. per min.

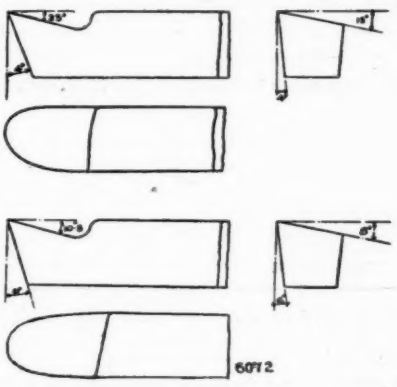


FIG. 10.

Results of the physical, mechanical, and chemical tests of the materials operated upon.

1. *Physical.*—The *density*, or weight in lbs. per cubic foot, of these materials was determined in the Physical Laboratory of the School, by Mr. Arthur Adamson, Lecturer in Physics. Two specimens were cut from each of the six bars, and the average of each pair is given in the annexed Table XXII.

Table XXII.—Table of Densities.

In lbs. per cubic foot.

	Determined by A. A.
Soft Steel	490·8
Medium Steel ...	490·4
Hard Steel	490·0
Soft Cast Iron ...	443·4
Medium Cast Iron ...	447·4
Hard Cast Iron ...	454·2

TABLE VIa.—TESTS MADE WITH

Description of Tool Steel used.	Material Operated upon.	No. of Trial.	Actual. Speed.	Cut.	Traverse	Area of Section of Cut.
Ordinary Water Hardened ...	Soft Steel	17	31·2	0·0585	0·0625	0·00365
,, ,, ,, ...	,, ...	18	25·1	0·1765	0·0625	0·01104
,, ,, ,, ...	,, ...	23	40·9	0·1885	0·0625	0·01180
,, ,, ,, ...	,, ...	25	61·75	0·0620	0·0625	0·00378
Ordinary Mushet	,, ...	19	35·1	0·1810	0·0625	0·01130
,, ,, ...	,, ...	20	35·2	0·1805	0·0625	0·01128
,, ,, ...	,, ...	21	40·5	0·1740	0·0625	0·01088
,, ,, ...	,, ...	24	63·0	0·0580	0·0625	0·00362
High-speed Air Hardened ...	,, ...	26	25·4	0·283	0·375	0·1065
Ordinary Water Hardened ...	Medium Cast-iron ...	75	24·6	0·0625	0·0625	...
,, ,, ,, ..	,, ,, ...	73	17·6	0·1875	0·0625	..
,, ,, ,, ..	,, ,, ...	77	15½	0·1875	0·125	...
,, ,, ,, ...	,, ,, ...	70	15	1⅛	½	Tool
,, ,, ,, ...	,, ,, ...	71	16	1⅛	½	,,
Ordinary Mushet	,, ,, ...	72	23·6	0·0625	0·0625	..
,, ,, ...	,, ,, ...	74	19·1	0·1875	0·0625	...
,, ,, ...	,, ,, ...	76	15	0·1875	0·125	...
,, ,, ...	,, ,, ...	78	16	0·1875	0·125	..
Ordinary Water Hardened ...	Soft Cast-iron... ...	178A	22·5	0·1915	0·125	...
,, ,, ,, ..	,, ...	178B	23·1	0·1910	0·125	...
Ordinary Mushet	,, ...	181	31·6	0·1860	0·125	...

The hardness was determined by drilling a piece cut from each sample with a standard drill loaded with a constant weight, and rotated at a constant speed in all trials. As is not unusual, a diagram apparatus was employed to give a written automatic record of the result of each trial. Vertical motion of the pencil, on the diagrams here reproduced, Fig. 11, represents number of revolutions of the drill, whilst horizontal motion represents distance drilled. Thus the tangent of the angle of slope of the line is a measure of (this kind of) hardness. It may be enumerated, also, as the number of revolutions of drill required to penetrate each one-hundredth of an inch of depth.

The effects of temper and sharpness of the drill are taken account of by drilling the standard sample of material at frequent intervals.

The tests will be reproduced in Table XXIII., and the diagrams have been traced off the original cards, and are given in Fig. 11.

2. *Mechanical Tests.*—Three specimens each for both tension and compression tests

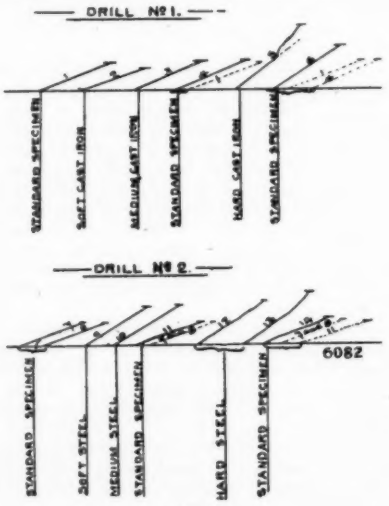


FIG. 11.

ORDINARY STEEL TOOLS.

Duration of Trial.	Horse Power. Electrically Measured. Gross.	Lost.	Net.	Area Machined sq. ft. Total.	Per Min.	Weight Removed lbs. Total.	Per Min.	Cause of Withdrawal.	Cutting Force on Tool.
Minutes.									Lbs.
20·0	11·95	9·95	2·00	3·26	0·163	7¼	0·362	Time up	2,110
5·0	8·76	6·17	2·59	0·65	0·131	4	0·800	Tool failed ...	3,407
5·75	10·21	6·62	3·58	1·22	0·214	9½	1·65	,, ...	2,890
6·62	12·15	10·00	2·15	2·11	0·319	5¼	0·792	,, ...	1,030
20·0	12·96	9·76	3·20	3·67	0·183	27¼	1·362	Time up	3,005
3·16	10·01	5·64	4·37	0·34	0·171	3½	1·105	Tool failed ...	4,090
13·0	12·30	9·80	2·50	2·75	0·211	18½	1·420	,, ..	2,040
17·0	12·25	10·15	2·10	5·55	0·326	13½	0·794	,, ...	1,010
5½	34·90	11·49	23·4	0·75	0·136	47	8·55	Time up	30,600
17·0	...	...	...	2·19	0·128	3¼	0·191	Tool failed ...	...
8·37	...	..	..	0·765	0·091	5	0·600	,, ...	...
·83	...	...	...	...	...	1	1·2	,, ...	...
refused	to cut	at 15ft.	per min.	...	...	...	...	,, ...	...
,,	,,	at 16ft.	,,	...	...	...	...	,, ...	...
20·5	8·1	...	...	2·51	0·122	5¼	0·256	,, ...	...
12·33	...	...	...	1·22	0·099	8¼	0·668	,, ...	..
1·5	...	...	...	...	...	1¾	1·165	,, ...	...
8·53	...	...	...	...	...	8	0·94	,, ...	...
8·53	...	...	...	1·0	0·117	13¾	1·55	Tool failed ...	...
8·8	8·65	6·0	2·65	1·06	0·120	13	1·48	,, ...	3,790
32·75	...	...	...	5·36	0·163	73½	2·25	,, ...	...

as to elastic limit, ultimate strength, and modulus of elasticity, were cut from each of the six materials operated upon. These tests were made in the Materials Testing Laboratory of the School by Mr. W. C. Popplewell, M.Sc. The results will be given in Table XXIV.

3. *Chemical Tests.*—The chemical analysis of each sample was performed in the Metallurgical Laboratory of the School by Mr. E. L. Rhead, Lecturer in Metallurgy. The samples analysed were taken from one end of the bar in each case.

The results are contained in Table XXV.:—

Table XXV.—Table of Chemical Composition of Materials.

Substance.	Percentages. Soft Steel.	Medium Steel.	Hard Steel.	Substance.	Percentages. Soft Cast Iron.	Medium Cast Iron.	Hard Cast Iron.
Carbon	0·198	0·275	0·514	Combined Carbon	0·459	0·585	1·15
Silicon	0·055	0·086	0·111	Graphite ..	2·603	2·720	1·875
Manganese ..	0·605	0·650	0·792	Silicon	3·010	1·703	1·789
Sulphur... ...	0·026	0·037	0·033	Manganese ...	1·180	0·588	0·348
Phosphorus ...	0·035	0·043	0·037	Sulphur...	0·031	0·061	0·1614
				Phosphorus ..	0·773	0·526	0·732

TABLE VII.—SOFT STEEL.

1	2	3	4	5	6	7	8	9	10	11
Tool Steel Maker.	No. of Trial.	Front Cutting Angle $90°-(\beta+\ell')$.	Front Top Rake. $(\beta+\ell')$.	Front Clearance Angle. (C').	Side Cutting Angle. $(90-s)$.	True Cutting Angle. $\{90-(\text{Top rake in this plane}+\beta)\}$ At Start.	True Cutting Angle. $\{90-(\text{Top rake in this plane}+\beta)\}$ At Finish.	Height of Tool above Centre.	(β).	Cutting Arc
Object of Trial :—To obtain Maximum Cutting Speed.										
		Deg. Min.	Deg. Min.	Deg. Min.	Deg. Min.	Deg. Min.	Deg. Min.	Inches.	Deg. Min.	Inches.
A. W. ...	1	.....	.....	11 20	81 44	66 40	66 40	0·725	4 0	.....
Bu.	9	60 6	29 54	9 14	68 0	60 6	60 6	0·500	2 54	0·15
Br.	7	71 15	18 45	12 40	80 25	71 7	71 7	0·8125	4 40	0·17
Ca.	13	73 41	16 19	9 56	87 10	69 42	68 21	0·28125	1 39	0·19
Fi. ...	5	81 20	8 40	12 25	79 30	80 30	78 40	.....	.....	0·23
Os.	3	77 39	12 21	10 45	70 57	73 26	73 26	0·69	3 49	0·23
S. D. ...	15	74 11	15 49	16 3	80 4	71 16	71 16	0·125	0 44	0·17
V. M. ...	11	80 1	9 59	10 37	89 17	78 4	77 0	0·100	0 37	0·20
Object of Trial:—To obtain Maximum Cutting Speed.										
A. W. ...	2	70 38	19 42	10 0	80 0	61 34	60 3	1·0	5 37	0·340
Bu.	10	67 4	22 56	7 10	70 12	64 4	64 4	0·5	2 56	0·500
Br.	8	71 36	18 24	9 14	88 56	59 17	59 17	0·75	4 19	0·310
Ca.	14	72 14	17 46	8 3	86 25	72 1	67 44	0·5	2 56	0·325
Fi.	6	73 3	16 57	7 13	85 57	73 3	65 25	1·0	5 37	0·410
Os.	4	75 20	14 40	6 0	74 0	59 56	59 56	0.625	3 34	0·420
S. D. ...	16	78 55	21 5	7 30	76 18	55 45	55 45	0·125	0 45	0·240
V. M. ...	12	82 35	7 25	13 42	84 56	77 5	75 20	0·100	0 35	0·37
Object of Trial :—To Machine Maximum Area of Surface.										
A. W. ...	38	69 10	20 50	10 36	82 12	68 25	60 30	1·0625	7 30	0·42
Bu.	31	66 53	23 7	6 46	71 44	62 12	60 0	0·5	3 37	0·35
Br.	40	72 38	17 22	12 0	80 48	69 14	60 48	0·75	5 22	0·32
Ca.	29	73 46	16 14	15 25	78 40	70 2	62 4	1·0	6 18	0·34
Fi.	35	72 30	17 20	9 12	82 50	71 28	65 28	0·875	5 50	0·46
Os.	27	80 54	9 6	8 10	76 0	72 19	69 15	0·4375	2 41	0·44
S. D. ...	33	68 30	21 30	12 40	77 20	58 35	58 35	0·75	4 50	0·35
Object of Trial :—To Remove Maximum Weight per minute.										
A. W. ...	39	70 14	19 46	8 36	82 12	67 34	61 0	1·0	7 2	0·62
Bu.	22	66 44	23 16	9 15	70 40	63 44	63 44	0·5	3 16	0·65
Br.	41	72 24	17 36	12 42	80 48	68 24	60 14	0·75	5 36	0·62
Ca.	30	72 22	17 38	14 5	73 40	64 22	64 22	1·0	6 18	0·54
Fi.	36	74 39	15 21	10 30	81 24	71 45	67 45	1·0	6 45	0·77
Os.	28	77 45	12 15	10 38	70 40	66 34	63 14	0·75	4 46	0·65
S. D. ...	34	63 27	26 33	11 20	85 0	61 37	61 37	0·875	5 58	0·46

TABLE VIII.—MEDIUM STEEL.

1	2	3	4	5	6	7	8	9	10	11
Tool Steel Maker.	No. of Trial.	Front Cutting Angle $90°-(\beta+\epsilon')$.	Front Top Rake. $(\beta+\epsilon')$.	Front Clearance Angle. (C').	Side Cutting Angle. $(90-s)$.	Front Cutting Angle. $90-$(Top rake in this plane $+\beta$). At Start.	Front Cutting Angle. $90-$(Top rake in this plane $+\beta$). At Finish.	Height of Tool above Centre.	(β).	Cutting Arc.

Object of Trial :—To obtain Maximum Cutting Speed.

		Deg.	Min.	Deg.	Min.	Deg.	Min.	Deg.	Min.	Deg.	Min.	Deg.	Min.	Inches.	Deg.	Min.	Inches.
A. W. ...	79	76	49	13	11	12	0	8	30	69	6	67	23	0·375	2	34	0·200
Bu.	91	66	10	23	50	8	30	72	0	62	46	61	51	0·625	4	4	0·170
Br.	83	74	32	15	28	12	40	78	0	68	37	61	51	0·625	4	8	0·175
Ca.	89	71	20	18	40	11	20	82	10	69	42	64	37	0·750	5	18	0·160
Fi.	81	70	12	19	48	16	40	75	0	65	34	63	19	1·0	6	26	0·200
Os.	87	71	9	18	51	11	20	69	20	64	32	64	32	0·625	4	8	0·175
S. D. ...	85	75	49	14	11	13	45	73	55	68	4	65	14	0·625	4	16	0·150

Object of Trial :—To obtain Maximum Cutting Speed.

A. W. ...	80	74	51	15	9	9	50	79	20	72	32	67	42	0·375	2	28	0·375
Bu.	92	67	12	22	48	10	30	70	0	58	16	58	0	0·625	4	42	0·35
Br.	84	71	3	18	57	12	40	80	45	66	6	61	50	0·625	4	14	0·375
Ca.	90	71	12	18	48	11	20	82	50	66	4	61	50	0·75	5	26	0·35
Fi.	82	69	12	20	48	15	20	78	0	65	19	65	19	1·0	6	26	0·38
Os.	88	72	18	17	42	12	50	70	0	65	4	61	34	0·75	5	1	0·44
S. D. ...	86	77	36	12	24	14	2	69	20	66	5	65	8	0·75	5	16	0·38

Object of Trial :—To Machine Maximum Area of Surface.

A. W. ...	95	74	26	15	34	10	0	80	45	71	50	67	50	0·375	2	53	0·375
Bu.	94	68	9	21	51	7	10	70	40	63	14	62	14	0·625	4	36	0·4
Br.	99	71	5	18	55	10	0	79	47	68	20	66	16	0·5	4	50	0·35
Ca.	102	70	39	19	21	18	40	73	20	64	56	64	56	1·0	8	44	0·42
Fi.	97	76	33	13	27	16	42	73	20	63	10	63	10	0·375	2	50	0·4
Os.	103	69	32	20	28	14	42	70	10	62	15	61	10	0·624	5	45	0·45
S. D. ...	105	73	31	16	29	5	0	81	30	72	4	66	15	0·1875	1	46	0·42

Object of Trial :—To Remove Maximum Weight per minute.

A. W. ...	96	74	18	15	42	11	20	82	50	70	49	60	49	0·375	3	1	0·575
Bu.	93	65	8	24	52	7	30	68	10	58	24	58	24	0·625	4	32	0·675
Br.	100	74	18	15	42	11	20	80	50	68	12	65	15	0·4375	3	42	0·55
Ca.	101	72	50	17	10	20	35	72	0	64	45	62	30	0·8125	7	15	0·63
Fi.	98	71	14	18	46	10	36	71	20	67	47	65	40	0·5	4	3	0·75
Os.	104	67	43	22	17	14	2	72	0	63	6	61	10	0·8125	6	54	0·65
S. D. ...	106	71	0	19	0	7	10	80	45	69	32	63	22	0·125	1	38	0·575

TABLE IX.—HARD STEEL.

1	2	3	4	5	6	7	8	9	10	11
						True Cutting Angle.				
Tool Steel Maker.	No. of Trial.	Front Cutting Angle $90°-(\beta+\ell')$.	Front Top Rake. $(\beta+\ell')$.	Front Clearance Angle. (C').	Side Cutting Angle. $(90-\epsilon)$.	$90-$(Top rake in this plane $+\beta$) At Start.	At Finish.	Height of Tool above Centre.	(β).	Cutting Arc.
		Deg. Min.	Deg. Min.	Deg. Min.	Deg. Min	Deg. Min.	Deg. Min.	Inches.	Deg. Min.	Inches.
Object of Trial :—To obtain Maximum Cutting Speed.										
A. W. ...	139	74 5	15 55	10 58	84 0	72 44	64 21	0·375	3 14	0·2
Bu.	143	63 6	26 54	7 8	.....	67 26	66 44	0·375	3 16	0·22
Br.	133	71 9	18 51	11 19	80 5	68 31	69 49	0·5	4 8	0·225
Ca.	137	72 10	17 50	10 37	80 46	70 50	72 51	0·375	3 7	0·175
Fi.	131	66 22	23 38	12 41	73 38	63 45	63 45	1·0	8 15	0·26
Os.	141	71 5	18 55	14 2	72 40	65 25	.....	0·6875	5 55	0·27
S. D. ...	135	76 17	13 43	13 22	73 18	69 54	64 29	0·375	3 6	0·16
Object of Trial :—To obtain Maximum Cutting Speed.										
A. W. ...	140	74 40	15 20	9 55	84 18	74 21	68 0	0·375	3 20	0·35
Bu.	144	64 50	25 10	6 46	.....	65 29	64 14	0·375	3 21	0·43
Br.	134	69 3	20 57	8 53	79 2	67 5	.....	0·5	4 15	0·35
Ca.	138	70 7	19 53	9 55	80 46	70 7	68 49	0·375	3 11	0·31
Fi.	132	67 28	22 32	12 41	72 20	61 30	.....	1·0	8 30	0·47
Os.	142	72 12	17 48	14 2	77 40	66 12	.....	0·625	5 28	0·46
S. D. ...	136	75 41	14 19	13 22	74 37	68 57	68 57	0·4375	3 42	0·34
Object of Trial :—To Machine Maximum Area of Surface.										
A. W. ...	153	74 49	15 11	9 2	84 48	84 8	79 41	0·3125	3 11	0·4
Bu.	155	69 11	20 49	7 5	.....	69 11	62 21	0·25	2 49	0·42
Br.	145	71 21	18 39	14 2	74 30	68 41	.....	0·50	4 37	0·43
Ca.	149	79 24	10 36	12 58	80 46	75 55	.....	0·375	3 28	0·39
Fi.	157	68 20	21 40	11 35	71 30	61 23	.....	0·5	5 37	0·48
Os.	151	75 6	14 54	7 25	71 55	69 4	.....	0·375	3 35	0·40
S. D. ...	147	76 23	13 37	6 25	82 32	75 1	75 1	0·25	2 18	0·40
Object of Trial :—To Remove Maximum Weight per minute.										
A. W. ...	154	75 59	14 1	9 55	75 30	73 55	67 56	0·3125	3 24	0·56
Bu.	156	66 24	23 36	7 25	.....	66 58	62 8	0·25	3 2	.....
Br.	146	71 47	18 13	10 40	80 8	69 6	.....	0·5625	4 51	0·55
Ca.	150	78 7	11 53	11 20	78 40	73 16	71 55	0·375	4 3	0·60
Fi.	158	71 57	18 3	13 46	70 35	63 28	.....	0·5	5 22	0·77
Os.	152	76 55	13 5	7 25	72 0	68 52	65 43	0·25	2 28	0·65
S. D. ...	148	76 9	13 51	8 32	80 46	73 26	73 26	0·25	2 32	0·67

TABLE X.—SOFT CAST IRON.

1	2	3	4	5	6	7	8	9	10	11
						True Cutting Angle.				
Tool Steel Maker.	No. of Trial.	Front Cutting Angle $90°-(\beta+\ell°)$	Front Top Rake. $(\beta+\ell°)$.	Front Clearance Angle. $(C°)$.	Side Cutting Angle. $(90-s°$.	$90-$(Top rake in this plane $+\beta$). At Start.	At Finish.	Height of Tool above Centre.	$(\beta$.	Cutting Arc.
Object of Trial:—To obtain Maximum Cutting Speed.										
		Deg. Min.	Deg. Min.	Deg. Min.	Deg. Min.	Deg. Min.			Inches.	Deg. Min.	Inches.
A. W. ...	167	80 47	9 13	9 45	86 0	80 5	.....		0·25	1 23	0·175
Bu.	165	71 12	18 48	8 32	.....	68 17	.....		0·375	2 6	0·150
Br.	171	74 49	15 11	11 35	81 45	73 47	.....		0·375	2 11	0·220
Ca.	161	70 32	19 28	9 5	77 52	67 14	.....		0·500	2 46	0·175
Fi.	170	75 7	14 53	10 30	74 40	70 25	.....		0·500	2 53	0·20
Os.	163	77 58	12 2	6 14	72 46	70 54	.....		0·25	1 25	0·20
S. D. ...	159	78 1	11 59	6 35	85 40	78 1	.....		0·375	2 4	0·16
Object of Trial:—To obtain Maximum Cutting Speed.										
A. W. ...	168	80 19	9 41	9 45	86 40	80 19	.....		0·25	1 30	0·4
Bu.	166	69 31	20 29	7 25	.....	66 3	.....		0·375	2 9	0·34
Br.	172	77 10	12 50	9 45	80 35	74 47	.....		0·375	2 13	0·35
Ca.	162	71 48	18 12	13 55	78 41	69 50	.....		0·5	2 49	0·35
Fi.	169	72 6	17 54	10 46	74 10	67 29	.....		0·4375	2 31	0·42
Os.	164	75 54	14 6	8 15	72 30	68 36	.....		0·375	2 6	0·375
S. D. ...	160	80 46	9 14	6 0	87 38	81 29	.....		0·3125	1 45	0·35
Object of Trial:—To Machine Maximum Area of Surface.										
A. W. ...	182	79 19	10 41	7 50	86 45	78 37	.....		0·375	2 30	0·45
Bu.	177	71 5	18 55	7 42	.....	68 26	.....		0·25	1 34	0·47
Br.	185	75 52	14 8	10 28	81 28	74 10	.....		0·25	1 48	0·40
Ca.	173	75 48	14 12	9 45	79 45	73 25	.....		0·5	2 53	0·40
Fi.	179	74 24	15 36	15 55	70 10	66 4	.....		0·625	3 56	0·52
Os.	175	73 3	16 57	10 46	72 15	67 46	.....		0·375	2 14	0·42
S. D. ..	186	70 10	19 50	3 0	82 52	72 47	.....		0·25	1 50	0·45
Object of Trial:—To Remove Maximum Weight per minute.										
A. W. ...	183	79 28	10 32	8 50	86 55	79 28	.....		0·1875	1 18	0·6
Bu.	178	69 42	20 18	7 25	.....	67 48	.....		0·25	1 38	0·65
Br.	184	72 41	17 19	10 10	84 0	76 24	.....		0·1875	1 16	0·66
Ca.	174	76 20	13 40	10 46	79 14	71 34	.....		0·5	3 3	0·60
Fi.	180	74 16	15 44	14 20	74 53	69 14	.....		0·625	4 4	0·67
Os.	176	74 42	15 18	8 32	71 42	67 8	.....		0·375	2 18	0·62
S. D. ...	187	73 39	16 21	4 20	84 50	73 39	.....		0·125	0 58	0·67

TABLE XI.—MEDIUM CAST IRON.

1	2	3	4	5	6	7	8	9	10	11
Tool Steel Maker.	No. of Trial.	Front Cutting Angle $90°-(\beta+\epsilon')$.	Front Top Rake. $(\beta+\epsilon')$.	Front Clearance Angle. (C').	Side Cutting Angle. $(90-\varepsilon)$.	True Cutting Angle. $90-$(Top rake in this plane $+\beta$). At Start.	True Cutting Angle. $90-$(Top rake in this plane $+\beta$). At Finish.	Height of Tool above Centre.	(β).	Cutting Arc.
		Deg. Min.	Deg. Min.	Deg. Min.	Deg. Min.	Deg. Min.	Deg. Min.	Inches.	Deg. Min.	Inches.
Object of Trial:—To obtain Maximum Cutting Speed.										
A. W. ...	52	80 46	9 14	5 21	88 30	80 46	.....	.....	.....	0·20
Bu.	42	67 49	22 11	5 43	.....	67 10	.....	0·75	4 50	0·12
Br.	50	77 20	12 40	8 36	82 12	75 57	.....	0·5	3 26	0·15
Ca.	54	69 37	20 23	10 37	78 41	66 22	.....	0·625	4 20	0·16
Fi.	46	76 21	13 39	9 35	78 0	73 35	.....	0·5625	3 44	0·25
Os.	44	75 32	14 28	8 35	80 48	72 46	.....	0·8125	5 14	0·20
S. D. ...	48	77 35	12 25	8 54	85 42	76 53	.....	0·375	2 30	0·17
Object of Trial:—To obtain Maximum Cutting Speed.										
A. W. ...	53	78 21	11 39	4 45	88 55	79 23	.....	.....	.....	0·4
Bu.	43	.....	.....	8 11	.....	.....	.....	0·75	4 56	0·33
Br.	51	76 7	13 53	8 36	83 15	69 44	.....	0·5	3 16	0·32
Ca.	55	70 14	19 46	9 56	82 10	68 45	.....	0·625	4 23	0·4
Fi.	47	74 4	15 56	11 30	78 30	71 22	.....	0·5	3 14	0·4
Os.	45	75 54	14 6	8 54	80 48	73 8	.....	0·75	4 52	0·38
S. D. ...	49	73 25	16 35	7 48	84 15	74 5	.....	0·375	2 33	0·36
Object of Trial:—To Machine Maximum Area of Surface.										
A. W. ...	58	79 13	10 47	6 35	86 17	79 13	.....	0·125	0 52	0·45
Bu.	64	74 21	15 39	7 8	.....	71 43	.....	0·125	0 56	0·4
Br.	60	80 47	9 13	7 6	84 18	80 5	.....	0·2187	1 44	0·4
Ca.	56	73 56	16 4	10 37	.....	78 6	.....	0·625	4 4	0·3
Fi.	62	71 1	18 59	12 40	73 57	68 24	.....	0·5	3 36	0·45
Os.	68	78 52	11 8	6 27	72 0	75 25	.....	0·25	1 54	0·375
S. D. .	66	70 48	19 12	9 14	75 58	68 9	.....	0·25	1 51	0·33
Object of Trial:—To Remove Maximum Weight per minute.										
A. W. ...	59	81 19	8 41	5 10	88 0	81 19	.....	0·125	0 51	0·61
Bu.	65	77 26	12 34	8 35	.....	70 6	.....	0·125	0 54	0·66
Br.	61	76 6	13 54	12 0	84 18	75 25	.....	0·2815	1 54	0·61
Ca.	57	73 2	16 58	14 3	86 25	73 43	.....	0·625	4 17	0·5
Fi.	63	73 33	16 27	12 0	75 17	67 31	.....	0·75	5 8	0·64
Os.	69	79 9	10 51	7 8	74 38	73 1	.....	0·125	0 56	0·56
S. D. ...	67	73 20	16 40	9 14	76 18	70 42	.....	0·25	1 57	0·53

(The remainder of the Tables, viz. Nos. 12, 15–18, 20, 21, 23 and 24 will appear in the next issue.)

NEW MACHINERY & APPLIANCES

Military Tractor.

In the early part of last year H.M. Secretary of State for War offered three prizes, respectively of £1,000, £750, and £500, for the three best tractors for military purposes, fulfilling the conditions laid down by the War Department. The trials took place in October and November last, and the award of the first and only prize, together with a bonus of £180 for additional results beyond what was specified, has just been made to Messrs. R. Hornsby & Sons, Limited, of Grantham, for the only tractor that has fulfilled the conditions.

The engine which succeeded in carrying off the prize is illustrated herewith, and a general description of it follows. Before proceeding to this, it will be advisable, however, to review the conditions set down by the War Office in order to more thoroughly appreciate the work that the engine so effectively succeeded in carrying out.

The tractor was not to exceed a gross weight of 13 tons when fully loaded with all its fuel and water, and with all stores necessary for its proper manipulation in the march, and must be independent of any extraneous machinery for the supply of its motive power. It was to be able to complete a run of 40 mls., hauling a gross load of 25 tons, and at a speed averaging 3 mls. but not exceeding 5 mls. an hour over average roads with gradients up to 1 in 18. It was also to be able to run up to 8 mls. an hour on a level road with 12½ tons load, to climb a hill 1 in 6 with the same load, and to be able to ford a stream 2 ft. in depth. It was to be fitted with winding gear, carrying 75 yds. of flexible steel-wire rope, with a breaking-strain of not less than 15 tons, and capable of working fore or aft, or within 90 degs. either way. It was not to exceed 9 ft. high, inclusive of removable parts, by 7 ft. 4 ins. wide. It might be 20 ft. long.

On the following points the judges laid special stress: The total distance that a load of 25 tons could be hauled at 3 mls. an hour without recharging in any way; the price; the economy in working and maintenance; ease of manipulation; simplicity of design; absence of noise, smell, etc.; the prevention of damage by dust; and the capability of using fuel of varying description and quality.

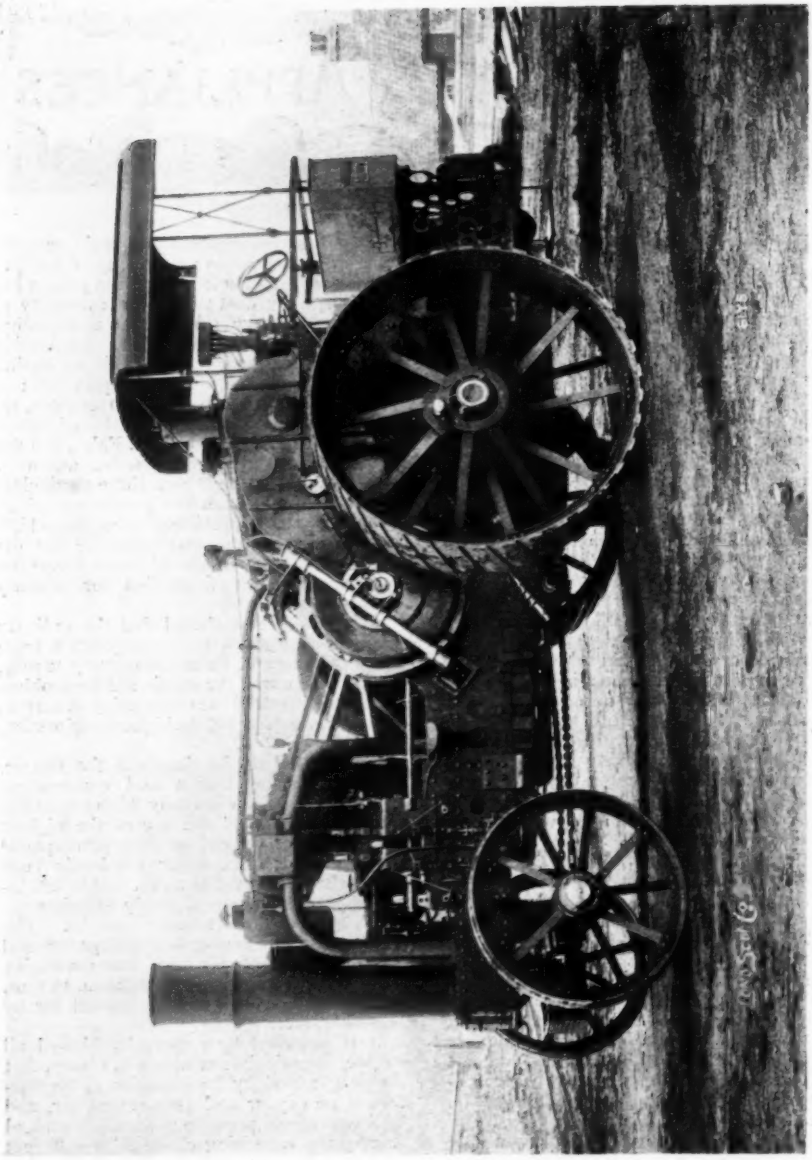
Other conditions applied to the motive power—in the case of steam engines, relating to the boiler, condenser, and liquid fuel; in the case of internal combustion engines, relating to the flash-point of the oil used, which must not be less than 75 degs. Fahr., and the starting-gear, and absence of noise and shock.

It will be gathered from these particulars of the conditions that the problem resolved itself into one for providing an engine of high power which, with every requisite for the generation of power, should come under the maximum weight demanded for military purposes.

When it is remembered that the ordinary steam road traction engine requires a fresh stock of coals and water about every 10 mls., it will be seen that the solution of the problem presented involved the overcoming of serious difficulties and needed the highest engineering skill.

To proceed to the details of the tractor. It is of unique design and construction throughout, the extremely high demands having necessitated the use of the highest grade of materials, and for some parts special materials that have never previously been used or tried for the purpose. This has involved a vast amount of costly experimental work, extending over many months. The tractor, which is mounted on springs fore and aft on four ordinary type traction-engine wheels, weighs, in running condition, 13 tons, of which about 10 cwt. is accounted for by oil, water, etc.

It is propelled by a Hornsby-Akroyd oil engine, the principle of which is, briefly, that the heat caused by the explosion of the mixture of oil vapour and compressed air, and by the act of compression of the air, is utilised to keep the vaporising chamber at sufficient heat to cause the explosions, so that neither electric spark nor ignition tube and flame is necessary, as is the case with other oil and



PRIZE MILITARY TRACTOR, BY MESSRS. R. HORNSBY AND SONS, LTD., GRANTHAM.

gas engines. The action is purely the working of natural forces, and is automatic when once the engine is started. To start, it is necessary to use an outside lamp for a few minutes to heat the vaporiser; but after this is done the vaporiser is kept sufficiently hot by the combustion and compression worked by the engine itself.

The engine has two cylinders, each 13 ins. diameter by 18 ins. stroke, placed one above the other, the lower one being horizontal and the upper one inclined, so that its longitudinal axis passes through the centre of the crank-shaft. The connecting-rods of both pistons are connected to a common crank-pin side by side. The crank shaft makes 350 revolutions per minute, and is fitted with a forged steel disc fly-wheel, 4 ft. 3 ins. diameter by 4 ins. wide.

The engine is constructed with the working cylinders open at one end to receive the pistons and closed at the other, except for necks connecting them with the vaporisers. The connecting-rods are attached at one end to the inside of the pistons, and at the other to the crank-pin, near to the cylinder back-ends; valve-boxes are fitted, each containing two valves, one being the air-valve and the other the exhaust-valve. These valves are mechanically opened by separate levers, each lever being moved by a cam mounted on a horizontal shaft driven through skew-gearing by the crank-shaft.

At the end of each cylinder is the vaporiser, which is a metal box made in two parts, one called the cold part—being water-jacketed—and the other the hot part. The vaporiser is open to the cylinder through the neck before-named. To enable the vaporisers to vaporise and ignite the oil pumped into them, the hot parts, at starting, are, as explained above, heated by external lamps; and when the engine has started these lamps are no longer required, the requisite heat being maintained by the internal explosions.

There are three oil-tanks, made of tinned sheet-iron, having a total capacity of 111 gals. These tanks are arranged between the frame under the crank-shaft and cylinders, and are filled by hand through a filler fitted with a strainer. The oil is drawn from the tanks by two small oil pumps—one for each vaporiser—and during the outstroke of the pistons, when they are drawing in air, forced into the vaporiser. On its way the oil passes through two vaporiser valve-boxes, each valve-box having two valves, one of which admits the oil to the vaporiser, the other being opened by the governor—whenever the engine is running too quickly—so as to allow some of the oil to flow back by the waste-pipe into the tank. The engine works on the "Otto" four-cycle principle, an explosion occurring in each cylinder alternately once in every two revolutions.

The lamps for heating the vaporiser are of the coil type, the coils being fixed inside a chimney, at the bottom of which is attached an oil cup, and the coil is attached by a three-way cock to a reservoir, to which is fitted a hand air-charging pump. They make the vaporisers sufficiently hot in about twenty minutes.

The engine is started by a compressed air and gas self-starter, the compressed air and gas being stored in a welded steel receiver arranged on the right-hand side of the engine, nearly under the fly-wheel. This is connected up to the lower cylinder only through a valve-box containing two valves—one for admitting the compressed air and gas, and which is actuated by a hand lever; the other is a check valve to prevent the starting ignition or explosion striking back into the receiver.

To start the engine—the vaporisers having been previously heated and a charge of oil pumped into them—the crank is placed slightly above the dead centre on the forward or explosion stroke of the lower cylinder. The starting valve is then quickly opened and closed, which causes an explosion in the lower cylinder, and starts the engine. Suitable shut-off valves are fitted on the reservoir, and a small valve-box with two valves for automatically charging it by admitting a portion of the gases of explosion at each working stroke. A geared fly-wheel hand-charging pump is fixed beneath the footplate on the right-hand side, to enable the reservoir to be charged should the pressure be allowed to run down.

The oil pumps are of solid gun-metal, and are fitted with double sets of suction and delivery valves, and are actuated by the air lever. The stroke of the pump is regulated to suit the load on the engine by quadrants actuated from the foot-plate by a hand lever. The engine is also stopped, and the charge of oil pumped into the vaporiser at starting by this hand lever.

The speed of the engine is regulated by a spring governor opening the vertical valve in the vaporiser valve-boxes and returning the excess oil to the tanks. The governor is arranged to be put out of action for the purpose of racing the engine when starting, or when extra power is required for short periods by a lever actuated from the foot-plate.

The cylinders are water-jacketed, and the water is circulated by a rotary pump round them and through a cooler under the

foot-plate. The cooler is of the "Clarkson-Capel" type, consisting of a series of brass tubes with spiral wire bound round the outside. The ends of the tubes are connected to aluminium headers. The water passes through the tubes, and air is drawn over the outside of the tubes by a "sirocco" fan arranged under the footplate behind the cooler. The air is drawn through the frame in front of the rear axle. The fan is driven by a longitudinal shaft by bevel gears from a cross shaft under the crank shaft. The cross shaft and rotary circulating pump are driven by a train of spur gears from the crank shaft.

A water column is arranged on the top of frame to provide for the expansion of the hot water. It is also fitted with a condensing coil to reduce loss by evaporation to a minimum.

To protect the cooler and fan from injury —should the engine sink in soft ground— flanged steel plates are fitted below them of suitable strength to support the weight of the engine.

The air is drawn from a silencing-box formed in the upper part of the frame between the crank shaft and cylinders, and consists of a box perforated at one end. Inside the box are arranged the ends of the air pipes, which have a long, narrow slot formed in them.

The main exhaust silencer consists of a box formed in the front end of the frame, into which the exhaust pipes from the engine cylinder are led. A chimney is placed at the top of this box, and is constructed to form a second silencer, it having an inner tube slightly smaller in diameter, with a dead end at the top. The exhaust from the main silencer is led by a pipe to the top of the inner tube, which it descends, and then passes upwards through the annular space formed by the inner tube and chimney to the atmosphere.

The engine, as fitted, is suitable for using refined Russian oil, but by having two additional cap ends for the vaporisers and adjusting the compression—means for which are provided on the small ends of the connecting rods—by changing the position of the steel compression plates, either refined American, Scotch shale, crude Russian, Astatki, Texas liquid fuel, and Burmah oils can be used. The engine, when using crude oils, would give off about 10 per cent. less power, and the vaporisers would require cleaning out every twelve hours. This can readily be done by a scraper through doors provided in the cap ends.

The propelling gear is started and stopped by a friction clutch attached to the pinion on the oil engine crank-shaft. The reversing is effected by bevel gears and a clutch on the first-motion shaft, and the various changes of speeds—four in number—by sliding pinions and wheels on the second- and third-motion shafts.

The levers actuating the friction clutch, reversing clutch, speed-changing gear, oil pump-stroking gear, accelerator for governor, hand-wheels of brakes on hind wheels, fourth-motion shaft, fly-wheel, and all lubricators are worked from the foot-plate.

The driving-wheels are 7 ft. diameter by 18 ins. wide; the front wheels, 4 ft. 1½ in. diameter by 8 ins. wide.

The competition was thrown open to engineers throughout the world, and it was rumoured that several firms—not only British, but American and German—contemplated entering the competition. Only Messrs. R. Hornsby & Sons, Ltd., however, persevered and faced the judges, and having gone through the trials satisfactorily, they are to be congratulated upon having been awarded not only the first prize, where a smaller award might have been made, but a bonus of £180, which represents, according to the conditions, that, instead of 40 miles, this tractor made a run of 58 miles with the store of fuel carried under the limit of weight, thus exceeding the demands by 45 per cent.

The trials took place over the well-known trial grounds near Aldershot, and included the rough roads and steep hills of that district, as well as the notorious Long Valley —a wilderness of soft sand, the nearest thing to the African veldt that England can produce. The engine travelled by road from Grantham to Aldershot—150 miles—and also home after the trials. The trials extended over 500 miles, and previous to this, over 200 miles had been done during the experiments in the neighbourhood of Grantham, in the uplands of Lincolnshire, so that over 1,000 miles has been run by the tractor with practically no signs of wear. After the trials at Aldershot, the engine was opened for inspection, and all bearings and wearing parts examined, and found in perfect condition.

Improvements in Textile Machinery.

SOME two years ago it was our privilege to inspect, and afterwards to give to our readers, an illustrated description of an important invention in textile engineering. We refer to the patents of Mr. Otto Hallensleben—an eminent German textile engineer — which consist, first, in the

interesting improvements he has been able to effect in the machinery used in the manufacture of carpets and rugs and of similar pile fabrics; and, secondly, to an entirely new method of dyeing or printing the yarn used in their manufacture, both of which combined are calculated to effect an extraordinary reduction in the cost of manufacture of these goods.

The dyeing machine and loom, as they were described and illustrated in the previous article,* represented what may be described as "experimental apparatus:" and a further period of two years spent in extensive investigation of the working of the machines and in testing the efficiency of the method has resulted in certain other and most important improvements being effected, which tend to still further reduce the cost of production.

In the first place, we will glance at the dyeing process as representing perhaps the more important of the achievements of Mr. Hallensleben.

For the benefit of those of our readers who are not familiar with the process of dyeing the yarn used in the manufacture of carpet, or with Mr. Hallensleben's earlier invention, we will briefly review them, in order that the new developments may be the more readily appreciated.

The object to be accomplished by any yarn-dyeing apparatus is to impregnate the yarn with several colours, at intervals and at such distances apart as the particular pattern may require. The mechanism at present in use for accomplishing this consists essentially of a drum *D* (Fig. 4), mounted upon a shaft, and capable of being revolved by a steam engine or other source of power through the intermediation of a ratchet *r*, each tooth of which represents a space on the surface of the drum which is to receive colour at one time. The yarns, having been wound on the drum from the bobbins *b*, are ready to be printed, which process is accomplished in the following manner.

Beneath the drum is a tramway *t*, on which a carriage *C*, containing a colour-trough, runs. This carriage, moreover, carries a small shaft, on which is mounted a colour pulley *P*, revolving in the colour mixture. When the printing operation commences, the carriage containing the colour-trough moves across the machine at each step or movement of the drum, by which

* *Cf.* FEILDEN'S MAGAZINE, Vol. IV., No. 5, pp. 580 *et seq.*

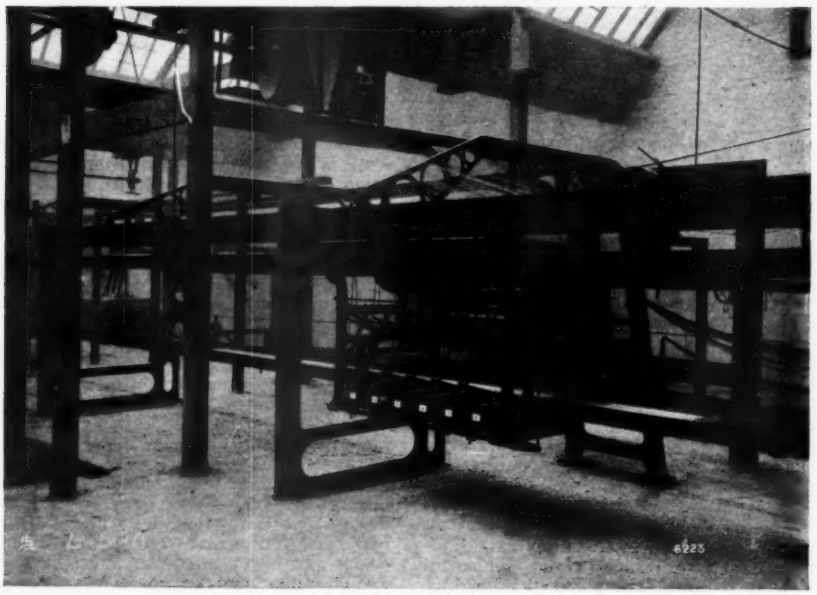


FIG. 1.—VIEW OF THE YARN-COLOURING APPARATUS: THE COLOUR CARRIAGE JUST COMMENCING ITS JOURNEY.

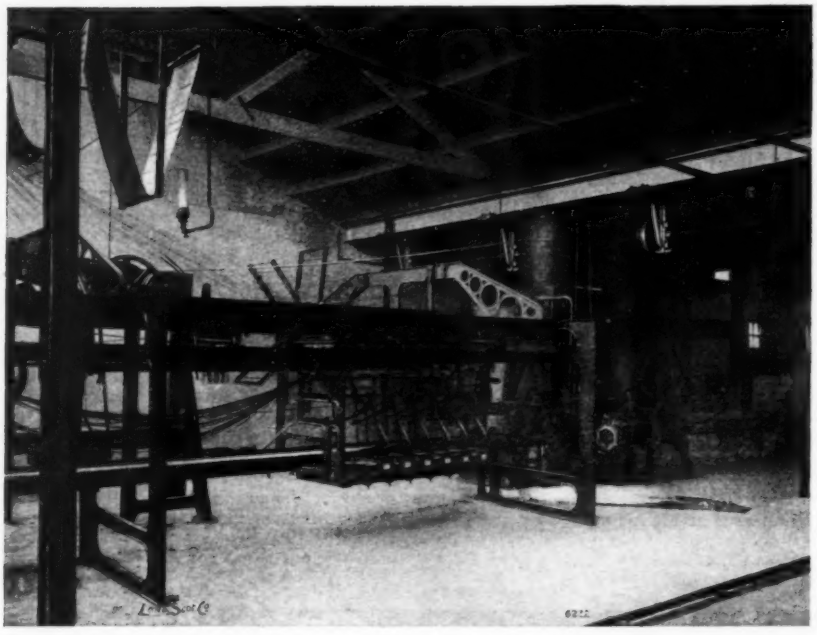


FIG. 2.—ANOTHER VIEW OF THE COLOURING APPARATUS: TO THE RIGHT IS SEEN THE STEAM TUBE INTO WHICH THE YARN, AFTER BEING COLOURED, IS PASSED TO BE FIXED AND DRIED.

means a line of colour is printed across the yarn. This process is repeated, the truck passing backwards and forwards, and the drum turning so as to expose the portion to be printed in each case, while the colouring receptacles containing the various colours are substituted one for another in agreement with the design, until the whole surface of the yarn wound on the drum has been treated, and shows, side by side, a series of stripes varying in width and colour. To facilitate the removal of the yarns the drum is provided with a collapsible section, by which the drum is thrown out of circle, thus enabling the assistants to place wooden rods beneath the oilcloth on which the yarn is wound, remove the cloth and yarn together for the final fixing, washing and drying processes to be performed, after which it is ready for the loom.

The drawbacks involved in the practice of this method, viz., the considerable number of operators required, the waste of colouring matter and the discontinuity of the various operations are dispensed with by the Hallensleben apparatus, which permits the whole of the above-mentioned operations to follow one another automatically.

In general construction and action the Hallensleben colouring apparatus resembles a slide lathe with its compound slide-rest, along the bed of which the yarn, wound to the length for the pattern to be printed, is firmly held in a horizontal position. The yarn is wound in lengths corresponding to those required on the colouring apparatus by a special automatic winding machine, requiring the attention of one man only, and the work of transfer is effected in a moment. The printing carriage, as originally arranged, ran automatically alongside the printing bed and was provided with two sets of gear, one for traversing and the other for printing. These operations were governed by a Jacquard machine in a way that, when the carriage had reached a section of the yarn on which colour was to be printed the traversing gear was uncoupled, and the printing gear coupled up. The carriage then passed on to the next spot to be printed, and these consecutive

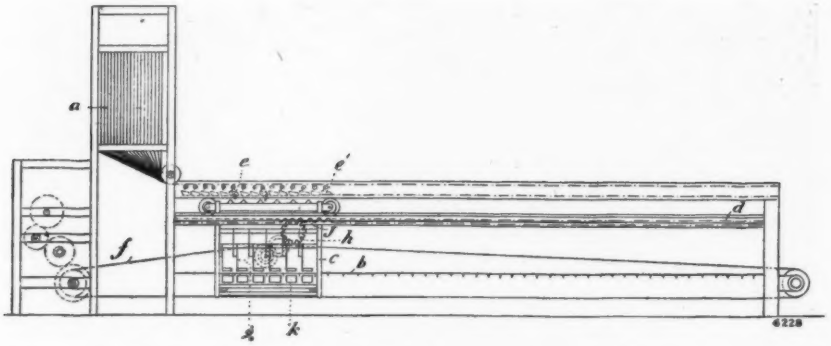


FIG. 3.—DIAGRAMMATIC SKETCH OF THE COLOURING APPARATUS.

operations were continued until the end of the printing was reached, whereupon a reversing movement was automatically thrown into gear, causing the carriage to return to its original position to receive a new colour. Meanwhile, the machine had required no attention.

Great as is the advance made by this machine over the older drum type, it will yet be seen that the colour-carriage could only be used for printing one colour at a time, and that for the second and succeeding colours it was necessary to bring the carriage back to the starting-point and refill the carriage receptacles. If, for instance, a carpet contained a pattern involving six different colours, the printing-carriage would have to pass six times along the length of the yarn. In the latest machine, however, which is to be seen in operation at the works of the Hallensleben Syndicate, Ltd., Byam Street, Fulham, all this has been changed, and the yarn can now be printed with all the required colours *in one single journey* of the printing-carriage. For this purpose the latter is furnished with a special printing device for each colour, and at each halt made by the carriage one or more of these devices is brought into activity, the desired device being controlled by means of a Jacquard machine. This latter controls rows of tumblers situated in the path of the carriage, each row of which is utilised for setting another colour in work. When the carriage makes contact with one or more of the tumblers which is turned up by means of the Jacquard machine, that printing device comes into activity which corresponds to the row of tumblers to which the turned-up tumbler

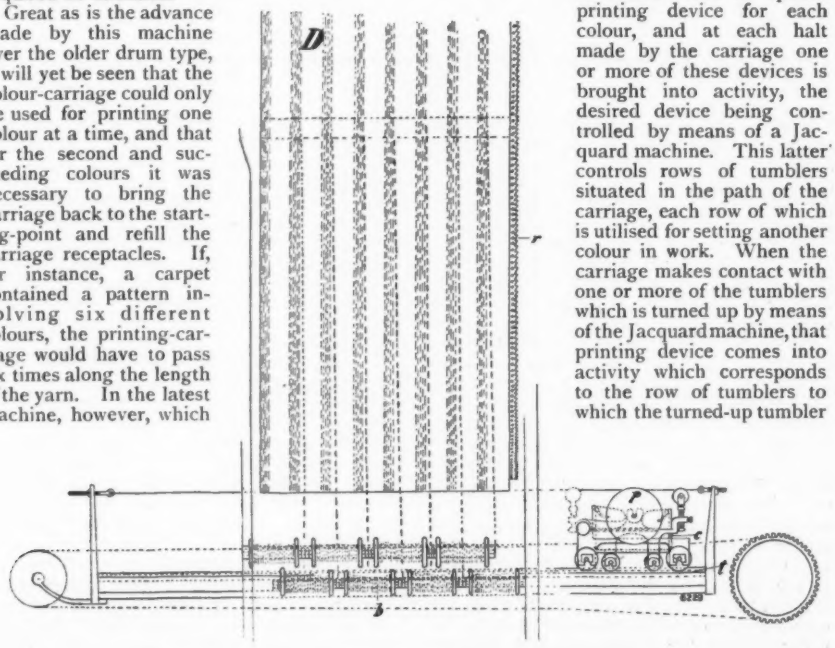


FIG. 4.—DIAGRAM ILLUSTRATING THE OLD DRUM PROCESS OF COLOURING YARN.

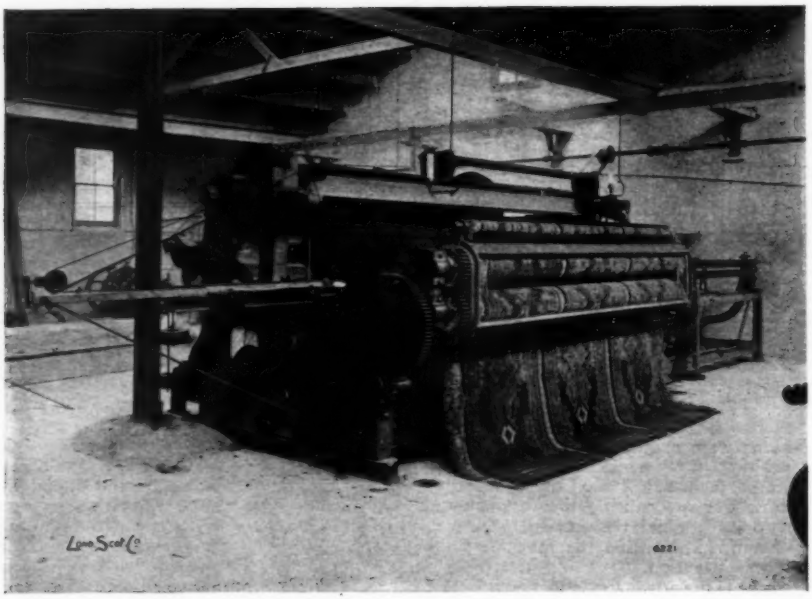


FIG. 5.—THE LOOM AT WORK, WEAVING SIX TURKEY RUGS AT ONE OPERATION.

belongs. After the printing has been accomplished, the carriage is again automatically moved forward to the next station where it encounters another turned-up tumbler, the printing device corresponding to this tumbler is brought into activity.

In Figure 3, *a* is the Jacquard, *b* the stretched yarn, *c* the printing carriage, *d* the rails upon which the carriage runs, *e* the tumblers arranged above the printing carriage and which can be turned by means of the Jacquard, *f* is the cord for driving the carriage, running over the pulley *g*, causing this to rotate, the motion being transmitted to the carriage by means of a spur-wheel *h* and a rack *j*. In the machine illustrated, six different colours have been provided for, colour-boxes being indicated by *k*. The operation of actually laying on the colour is performed by a colour pulley, to which, by means of a suitable apparatus, the colour is transferred, and which latter, by means of a reciprocating movement of the pulley, is laid on the yarn and distributed thereon by means of a plate provided in the colour reservoir, which rises as soon as the roller begins the backward and forward movement. The automatic laying on of the colour by this mechanism is of the greatest importance on account of the economy in labour: furthermore, the method of laying on the colour upon the upper side of the yarn, as well as underneath, which has not yet been achieved by any other printing machine, secures not only a better absorption of of the colour than has been attained by the laying on from below, but also, at the same time, in combination with an automatic measuring off of the exact quantity of colour secures a pronounced economy in material.

Additional colours can be introduced by adding further rows of tumblers and more colouring devices to the travelling machine, and the output doubled or trebled by introducing a further one or two travelling machines along the run, which working concurrently will consequently do the work in half or one-third of the time.

A further advantage over the existing method is that after colouring, the wool is immediately introduced into the steaming chamber, without the handling it undergoes under the present drum process, and the steam chamber in Hallensleben's machine using a much smaller amount of steam, considerably reduces the outlay under this head.

To sum up, the advantages of this important innovation, as far as the colouring process of the yarn is concerned, are the following :

All the operations are performed automatically, by which their accuracy and efficiency is enormously increased; and the saving in cost of labour is so great that the continuance of the old methods is regarded as hopeless.

Another Hallensleben invention, of almost equal importance to the colouring apparatus, consists in a special form of double-fabric loom, by which two connected pieces of pile fabric are woven simultaneously and by one operation, being separated, as the weaving proceeds, by cutting them through the centre. The essential features of this machine were fully described in the previous article before mentioned, and it will suffice to merely mention here that it has, as one of its principal features, a shuttleless operation, the weft being fed into the shed continuously by an ingeniously operated pair of tongs. Of greater importance, perhaps, is the feature which consists in the fact that, by weaving in of large bars of steel, both ground webs are kept constantly at a uniform distance from each other, and that the naps are cut exactly in the middle of their height by a series of cutters or blades which, in the machine as originally designed, were drawn through by means of an endless steel band automatically operated.

In the latest loom, however, the arrangement for effecting the cutting of the naps has been modified in such a way that there is no possibility of the cutting edge becoming blunted. The steel bars above mentioned are, in the new arrangement, provided with blades midway of their height and guides are provided which, after the bars are woven in, cause the blades to take a step-like position, one above the other, thus preventing the cutting edge coming in contact with the preceding bar when the lay beats up the weft.

The looms at present constructed and in operation are about 10 ft. in width, and in the illustration one is shown weaving six large rugs at one time. It will also weave two carpets, 9 ft. in width, at one operation. There is, however, no reason why looms of greater dimensions should not be constructed, capable of weaving fabrics up to, say, 30 ft. in width or more.

The above-mentioned features of the loom, together with the great strides made in the process of dyeing by the improved apparatus, make it safe to predict that the Hallensleben Syndicate, Ltd., of whom Mr. A. L. Jacobs is the pioneer, will practically acquire a monopoly in that branch of the weaving industry to which they refer, since patent rights for the apparatus and working process have been acquired for all countries.

Electrification of the Liverpool and Southport Section of the Lancashire and Yorkshire Railway.

LITTLE more than six months has elapsed since the first British railway to abandon the steam locomotive in favour of electric methods of propulsion effected its conversion, and the first electrically-driven train passed through the Mersey Tunnel.*

Since that time much progress has been made in the same direction, and it would appear that at no very distant date most of the steam-worked local and suburban lines, especially those at present affected by electric tram companies, will have abandoned the time-honoured locomotive.

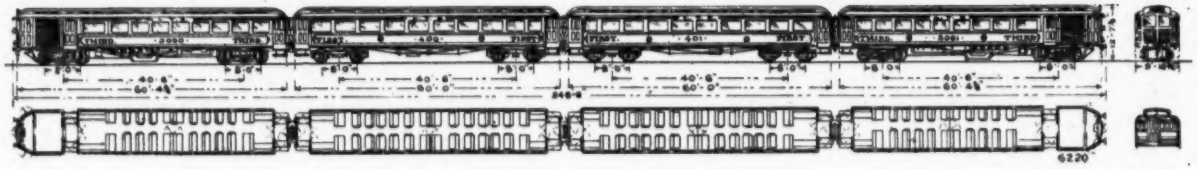
Reference is made elsewhere in this Review to the traction developments that are taking place on the North-Eastern Railway system in the Newcastle district, and since the appearance of the last number an entirely satisfactory run has been made with one of the new four-car electrically-propelled trains between Southport and Formby on the Lancashire and Yorkshire Railway. It is little more than twelve months ago since it was first announced that this company intended to electrify the portion of their line between Liverpool and Southport, and although at that time much of the detail of the work had to be decided, a start was made early last year upon the work, which is now rapidly approaching completion. The original scheme has been extended to include a service of trains at certain times of the day as far as Crossens, on the north side of Southport, so that the amount of track electrified amounts in all to about 23 mls. of double line.

A general description of the electrification will be acceptable at this stage of the work, although we shall return to the subject in a later issue, when the drawings and full details have been placed at our disposal.

Briefly, the trains generally are composed of two first and two third-class cars, the third-class cars of which are equipped with four motors of 150 h.p. each, making a total of 1,200 h.p. per train; to operate these motors current is obtained from a third rail, which is fed with direct-current at about 600 volts from four sub-stations, three of which are situated at Birkdale, Seaforth and

* *Cf.* FEILDEN'S MAGAZINE, Vol. 8, page 546.

VIEW OF ONE OF THE NEW ELECTRICALLY-DRIVEN TRAINS, LANCASHIRE AND YORKSHIRE RAILWAY.



PLAN AND ELEVATION OF ONE OF THE NEW TRAINS.

Sandhills respectively, and another in the main power-house at Formby. These sub-stations are provided to transform and convert the high-tension alternating current from the main power station at 7,500 volts, into direct current.

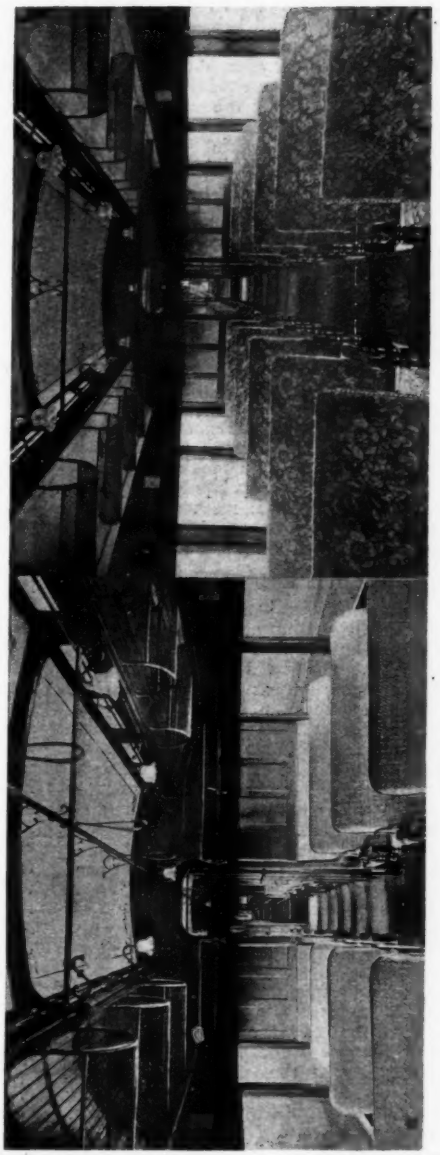
The power station adjoins the railway, on the banks of the river Alt, at Formby, is a building 290 ft. long by 130 ft. wide, and consists of an independent steel structure, the steel stanchions of which, in addition to carrying the roof, support travelling cranes over the engine-room, the spaces between the stanchions being filled with brickwork. It has two spans, one containing sixteen Lancashire boilers, 8 ft. 6 ins. in diameter, by 32 ft. long, for a working pressure of 160 lbs. per sq. in., together with superheaters, feed pumps, induced draught plant, etc.; the other and larger span contains four horizontal cross compound condensing engines of 1,500-k.w. capacity, also one subsidiary vertical compound condensing engine of 750-k.w. capacity, capable of taking large overload for short periods.

The generators in connection with these engines are of the three-phase type, with a periodicity of 25, and a voltage of 7,500. The engine-room also contains steam-driven exciters, sub-station plant, and a main switchboard.

Three-core paper-insulated metallic-sheathed cables convey the high-tension current to the sub-stations, and are laid on what is known as the "solid-system," at a suitable depth along the company's permanent way.

The sub-station equipments similar in character, consist of static transformers which transform the three-phase alternating current of 7,500 volts to low-tension alternating current, from which it is converted in rotary converters to direct current at 600 volts. The rotary converters are nominally of 600-k.w. capacity, four being provided in each sub-station, and three static transformers, cooled by means of air blast, are provided in connection with each rotary. The connections from these sub-stations to the third rail are made by insulated copper cables, run underground in troughing.

The permanent way is fitted throughout on the third and fourth rail system,



INTERIOR OF A FIRST-CLASS CAR.

INTERIOR OF A THIRD-CLASS CAR.

and consists generally of a live rail, of Vignoles section, commonly termed the "third rail," supported at intervals of 10 ft. on insulators, the centre of the rail being exactly 3 ft. 11½ ins. from the centre line of the track, and the top of the rail 3 ins. above the surface of the track rails, these being dimensions agreed upon between all the railway companies.

This third rail is of special steel, and of course of ample section, weighing 70 lbs. to the yard, in order to convey the full amount of current required to the trains, when between two sub-stations, without causing any appreciable loss in voltage; the different lengths of this rail being bonded with copper bonds to maintain the conductivity; it is carried by special insulators, and generally placed in the six-foot way, but occasionally brought to the outside of the track, to suit special conditions. At all level-crossings the third rails are bonded with cable underground.

In order to ensure an excellent return circuit an exactly similar rail to the third rail, supported on wooden blocks, has been placed in the four-foot way, bonded of course to each running rail, this method of return interfering least with the running tracks and permitting the easy removal of any running rail at any time.

The electric cars for this service are 60 ft. long and 10 ft. wide, being the widest carriages in this country. This width was adopted because it was found before any operations were begun that it was possible on the Southport line, as distinguished from other parts of the main line, to have wider stock, some slight alterations to the permanent-way and some trifling ones to the platforms along this length alone being necessary. The carriages have centre passages throughout, with vestibles to allow passage from one carriage to the next.

The motor vehicles are at the end, and third class; and, as previously described, are equipped with two 150-h.p. motors on each bogie.

The outer end has a small compartment for the motorman, containing all the apparatus for controlling the train; and near this is a luggage compartment, the remainder of the vehicle being devoted to passengers.

Most of the seats are cross-wise, to seat three on one side of the passage and two on the other, but at the ends they are fixed lengthwise, to allow more room for passengers entering or leaving the cars.

The cross seats are reversible, so that passengers may sit as they choose.

The seats are all covered with rattan, a very clean and healthy kind of cane seating. The interior of the cars is fitted with oak, giving a very light appearance

The trailers, or first class-cars, have seats arranged after the same design, but only two on each side of the passage; they are upholstered in "epingle," the interior decoration being mahogany, with light wood panelling, and the roof covered with millboard.

Special attention has been given to the electric lighting and heating of these vehicles.

The question of cleaning has been carefully considered, and a new vacuum cleaning plant, embodying the latest principles for extracting dust and dirt from cushions, etc., is being installed, with which all these trains will be regularly cleaned.

A four-car train will carry 270 passengers, the third class seating 69 and the first class 66 people.

Perhaps it is well to mention that in order to run a satisfactory suburban service it is necessary that the delay at stations should be reduced to the smallest possible amount, and this will entail alterations in the method of dealing with baggage, as it is not to be expected that the electric trains can carry heavy luggage. Notice boards will be hung on the platforms showing passengers where to stand to await their class, and in order to ensure quick loading and unloading of passengers, strict regulations will be made that every passenger is to enter the carriages at the end door and leave by the front door, thus ensuring a continuous circulation.

In view of the alarm caused within recent months by fires on electric trains, it will be interesting to note that the company have taken all possible precautions against any such an occurrence. The motor compartments have, with the exception of the roof, which is covered with sheet-steel plates, been lined with uralite, a well-known fire-proof material, the floor also being fire-proof. In addition to the cable troughs, in which the cables are placed for conveying current to the motors and equipment, being lined with uralite, the whole of the floor over the motors is covered with the same material and thin steel plates. All the trains carry fire appliances, and ample steps have been taken to ensure safety in this respect, though the danger on surface lines is practically *nil*. The passengers will be able to feel that they are just as comfortable and as safe as in any steam-worked train.

The vacuum brake used on the trains is, with some slight differences, the same as that used all over the Lancashire and Yorkshire Railway. It is fitted with quick-acting valves, and, as will be seen, an exhauster must be provided in place of the steam ejector on the locomotive. This is the first

case of the use of the vacuum brake upon electrically worked trains.

The electrical equipment consists of four 150-h.p. motors on each motor-car with a controller capable of controlling all the motors on the train, together with the necessary switches, gauges, and circuit-breakers in each motor compartment. Under the floor of the cars are placed the resistances and reversers for the electrical control.

On each side of the bogie are cast-steel shoes, or slippers, which pick up the current from the live rail. The current is returned through the wheels to the running rails, and thence to the centre rail, and then on to the power-house.

Between the carriages connections are provided for operating the rear motors from the front end.

When the service starts there will be a service of stopping trains in both directions between Liverpool and Hall Road, with not more than ten minutes' interval: every second train will go on as a stopping train to, or come from Southport, thus forming a service to Southport every twenty minutes. In addition to this, however, there will be an hourly express in each direction between Liverpool and Southport, and at certain times the trains arriving at Southport from Liverpool will go on to Crossens.

The stopping trains between Liverpool and Hall Road and those between Liverpool and Southport will be run in less time than at present, but it is not intended that the expresses to Southport shall do the journey in less time than the fastest steam trains now running.

The whole of the work with the exception of the rolling stock, which is being made at the Horwich and Newton Heath Works of the railway company, is being carried out by Messrs. Dick, Kerr & Co., Ltd., of London and Preston, who are now fast completing at their Preston works the main and subsidiary generators, the sub-station equipment, the control equipments of the trains, and other electrical plant.

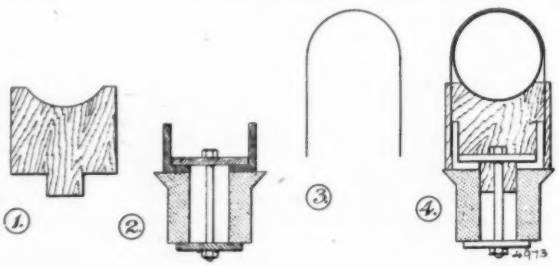
WORKSHOP PRACTICE.

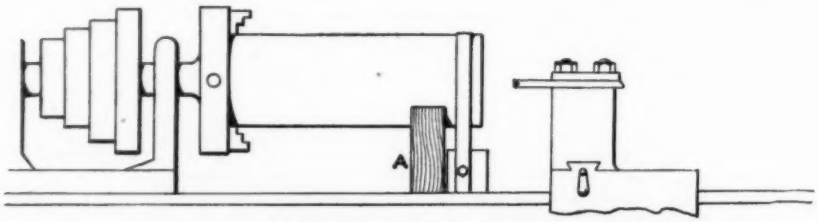
This Supplement is set apart for the description of New Tools and Appliances, and for discussion of matters relating to Works Management, Tools, the Machine Shop, Foundry, Pattern Room, and General Practice, both Mechanical and Electrical. It is of prime interest to Works Managers, Foremen, etc., from whom contributions, which are paid for, are cordially invited.

A Large Stay for a Small Lathe.

A short time back I had a length of steam tube, 6 ins. in diameter and 19 ins. long, that required screwing internally at each end for a distance of 1 in. with a Whitworth thread, 11 to the inch. The lathe was a light screw-cutting one of 6½-in. centres; width of bed 8 ins.; and a light self-centering 3-jaw chuck with ¾-in. stops on the dogs. When held in the chuck the tube was of course very springy on the extreme end, and required a steady before it could be machined. Not having a 3-pin steady or even an ordinary steady that would suit the lathe and the job, I set to work to arrange one as follows:—First, a block of wood (*A*) was cut to the shape of Fig. 1 and placed under the pipe in the position shown, making it a good fit in the bed of the lathe, and sufficiently tight against the pipe to just allow the lathe to revolve when pulling round by hand. Next, two small angle-plates were bolted to the bed of the lathe in the position and manner shown at Fig. 2. Then a strip of wrought-iron was bent round to the shape of Fig. 3, and drilled to suit existing holes in the angle-plates. Fig. 4 shows the completed stay.

W. C. M.

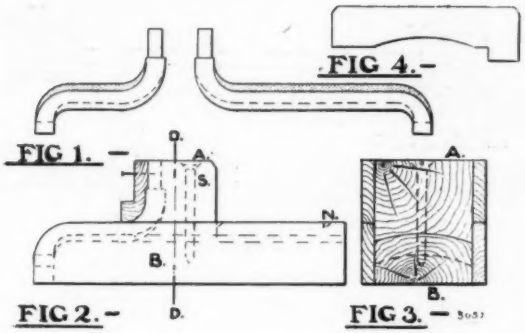




A LARGE STAY FOR A SMALL LATHE.

An Adjustable Steam Port Core-Box.

In making the patterns for a set of standard engines, we had in the steam cylinders, to provide for two sizes of steam-port cores, owing to these being of different lengths. For ordinary work the making of two core-



AN ADJUSTABLE STEAM PORT CORE-BOX.

boxes would have been of little moment, but it appeared under the circumstances to be a waste of time and material making so many patterns practically in duplicate. Skeleton boxes, as also the dodge of making one box of the longest length required but having a piece of its section made movable in order to shorten same for the second size, were out of keeping with the work required of standard patterns. It might appear odd that the designer created this extra work, while a simple arrangement of parts generally avoids such trouble; but the real cause arose from having to make each cylinder suitable for two different strokes. The plan hit upon is the one here described and shown, which enables one such core-box to make very readily any length of core required for each size of cylinder; and while they answer well for such special work, for doing odd jobs and meeting emergencies they are found most convenient. Fig. 1 shows two such cores, made from the single box (Fig. 2), which is built up in two parts, the top part *A* fitted and sliding upon the bottom part *B*. Notches, as at *N*, indicate the position to set *A* upon *B* when adjusting box for the second size of core. The single wood screw *S* secures the parts after adjustment is made, and also is used to prevent the parts getting separated when stowed in the loft. Fig. 3 is a section of box at its deepest part *DD*, showing its top part made with bottom concave, and resting upon the convex top of the bottom part *B*. The flanges, fitted to each part to partly enclose box, act perfectly as guides. An ordinary strickle (Fig. 4) is employed in the usual way to form the radial top of the cores.

J. C.

Improving a Scribing-Block.

The scribing-block in question was a large one, the base being 15 ins. in diameter and the pillar about 5 ft. high. The base was originally like Fig. 1, the facing being about $1\frac{3}{4}$ in. wide. When the needle was being used near the top of the pillar, the vibration set up at the pointer, due to the rubbing of the base over the slight inequalities of the table, completely spoilt the drawn line, which appeared wavy and varying $\frac{1}{8}$ in. in height. Powdered blacklead sprinkled plentifully on the table helped matters a little. But finally the scribing-block was put in the lathe, and a concentric groove turned in it. The section of this groove (Fig. 3) was part of a circle ($\frac{7}{16}$ in. diameter). A hole was drilled down vertically to meet the groove. The requisite number of balls ($\frac{3}{8}$ in. diameter) were dropped down this hole and thus

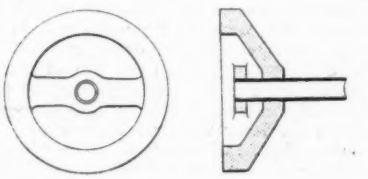


FIG. 1.

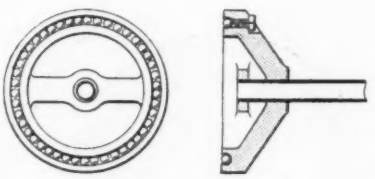
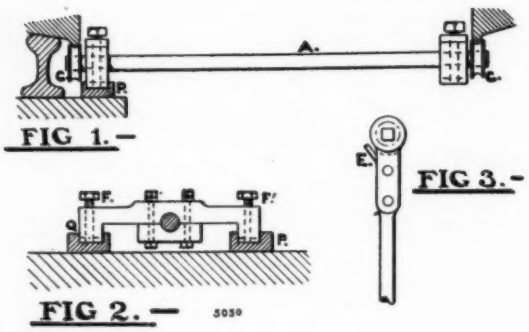


FIG. 2.

FIG. 3.

IMPROVING A SCRIBING-BLOCK.

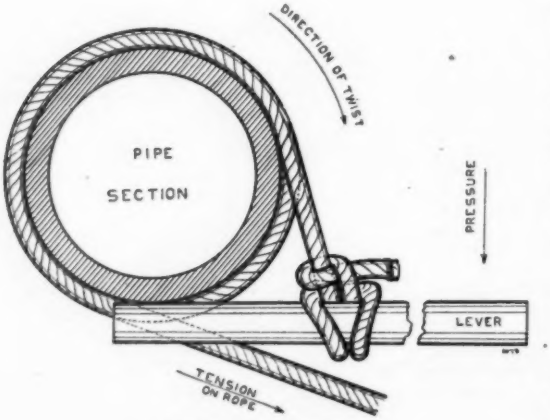
into the groove. The hole was closed by a set screw, as shown at Fig. 2. The balls project very slightly below the base, and as the width of the groove at the base is less than the diameter of the balls they cannot drop out. The scribing-block treated in this way was found to answer quite satisfactorily, standing firm, without any rocking, and capable of being moved about quite easily. A notable feature was the ease with which the scribing-block revolved about its centre, enabling the pressure of the pointer on the work to be adjusted with great nicety. E. H. D.



TRYING OVER LOCOMOTIVE VALVE GEAR.

An Inexpensive Pipe-Wrench.

The drawing shows an easily-made device for use in pipe-fitting when a suitable pipe-wrench is not available. One end of a good manilla rope is tied securely a short distance from the end of a bar or pipe of iron, to be used as a lever. It is then given one turn round the pipe to be wrenched, in the opposite direction to the one in which the pipe is to be twisted; the end of the bar resting on the pipe as shown. The other end of the rope is held taut. On pressing down the lever the grip of the rope on the pipe tightens, while when the bar is lifted the rope slackens and slides round the pipe ready for another grip. J. A. S.



AN INEXPENSIVE PIPE-WRENCH.

[A length of chain may be also employed for the purpose attached to lever by a bolt. —ED.]

Trying Over Locomotive Valve Gear.

A good and accurate method of trying over locomotive valve gear is shown at Figs. 1, 2, and 3. The parts consist of a 1½-in. square bar of mild steel *A*, which just stretches in between the rails of the engine pit. At such a distance from the ends as to allow two small rollers about 3½ ins. diam., *C* and *C*, to be slipped on, which take the flanges of the driving wheels, are turned two journals upon which are put the carriages, as shown in Fig. 2. Through the ends of each carriage are put set screws *F* and *F*. Upon the middle of the bar is put the ratchet, shown in Fig. 3, which has square teeth on the wheel and also the square hole in the centre. The paul *E* can be sprung to take either direction of motion by aid of a spring in the centre of the lever. Before the weight is taken on the driving wheel springs, the apparatus is slipped under the wheels; under each set screw *F* is put a shoe *P*, which takes the boss *Q* which is on the ends of each carriage. The set bolts are then screwed down until the weight is taken. It is now quite easy to get motion among the gear in any direction by reversing the ratchet (Fig. 3), even to the smallest part of a revolution, without moving the locomotive. LOCO. MAN.

ENGINEERING ABSTRACTS

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Inl. I. E. E.	Journal of the Institution of Electrical Engineers	London	Varies from 1/6 to 7,6
Jnl. Iron & Steel Inst.	Journal of the Iron and Steel Institute	London	16/– per vol. (two annually)
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Jnl. Soc. Arts	Journal of the Society of Arts	London	–/7
Jnl. Western Soc. Eng.	Journal of the Western Society of Engineers	Chicago, U.S.A.	3/–
Knowledge	Knowledge	London	–/7
La Mach.	La Machine	Geneva	5/– 6 mos.
Light Rly. & Tram. Jnl.	Light Railway and Tramway Journal	London	1/1
Machinery	Machinery	New York	2/–
Marine Engr.	Marine Engineer	London	1/1
Marine Engg.	Marine Engineering	New York	2/–
Mech. Wld.	Mechanical World	Manchester	–/3
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Nature	Nature	London	–/7
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Pract. Eng.	Practical Engineer	.....	–/6
Proc. Am. Soc. C.E.	Proceedings of the American Society Civil Engineers	New York	Mbrs. only
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Proc. Inst. C. E.	Proceedings of the Institution of Civil Engineers	London	Mbrs. only
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Proc. Roy. Phil. Soc. Glasgow	Proceedings of the Royal Philosophical Society of Glasgow	Glasgow	10/6
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Surveyor	Surveyor	London	–/4
Techy. Quarty.	Technology Quarterly	Boston	5/–
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Zeitschr. Vereines Oster. Ing. und Arch.	Zeitschrift des Oestereichischen Ingenieur und Architekten-Vereins	Vienna	1/4
Zeitsch. Vers. Deutsch. Ing.	Zeitschrift des Vereins Deutscher Ingenieure	Berlin	2/–
Zeitsch. Elektrotechnik.	Zeitschrift fur Elektrotechnik	Vienna	1/4
Zeitsch. Elektrochemie	Zeitschrift für Elektrochemie	Halle à S., Germany	2/–

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MATERIALS AND MEASUREMENTS.

Rotary Cement Kilns.

In Germany two forms of the rotary kiln are used, one for the dry and the other for the wet process. The kiln employed in connection with the latter is shown in Fig. 1, and consists of an inclined slowly-rotating cylinder, 2 m. diameter by 30 m. long, supported by metal rollers kept cool by water. Into the lower end of the cylinder a tube is inserted, through which coal dust is blown in by a current of hot air. Beneath the lower end, and arranged to receive the clinker as it falls out, is a cooling cylinder, from which the hot air is exhausted by means of a fan. The ingredients, in the form of "slurry," are fed in at the upper end of the kiln, where they rapidly dry, and form into little balls. These are met by the flame from the blast, and the resulting clinker, having traversed the length of the kiln, falls into the cooling cylinder, from which it is delivered sufficiently cooled to be handled without inconvenience. The only difficulty rests in the pulverisation of the coal, which requires very careful treatment; but particular attention must be paid to the ventilation. The kiln lining is made extra thick where the heat is greatest, and resists the high temperature in a satisfactory manner. The Danish kiln (Fig. 2) is constructed on the same lines, except that it is somewhat smaller, and there is no cooling cylinder; while the lower end of the kiln is closed by a shutter, through a hole in which the cool blast passes. This shutter is periodically opened to let the clinker out. The upper end of the kiln terminates in a brick chamber, from which the gases escape by a suitable flue. In the American kiln (Fig. 3) the materials are introduced through a tube at the upper end of the roasting cylinder, and, on leaving the lower end of this, the clinker falls into a cooling cylinder, then passing between crushing rollers, and finally into a second cooling cylinder, of which there is one to every two kilns. —**A. Morel,** *Gén. Civil, Vol. XLIV, No. 5,* pp. 68-70.

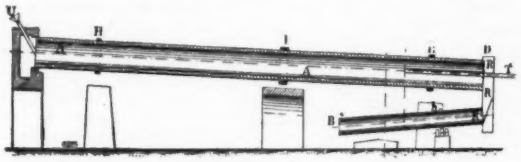


FIG. 1.

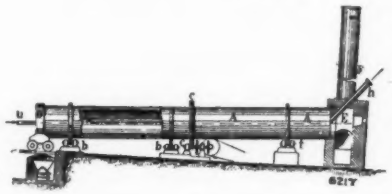


FIG. 2.

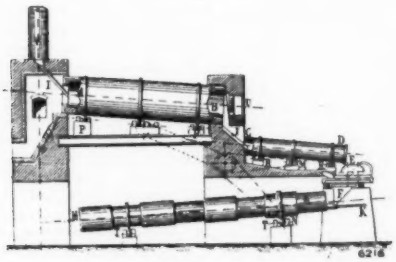
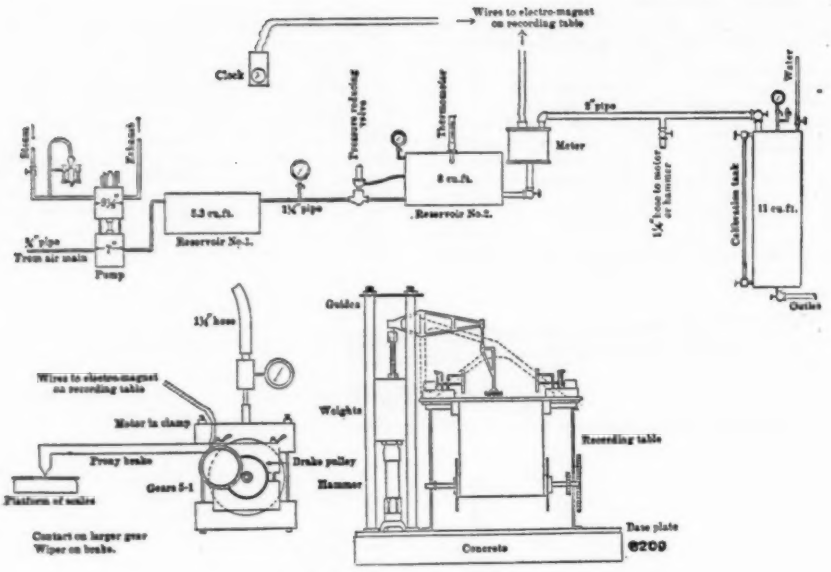


FIG. 3.

ROTARY CEMENT KILNS.

Methods for Testing Air Motors and Hammers.

The apparatus and methods described below are those used in some extensive tests of air-drill motors and air-hammers, and these tests were made for the purpose of determining the air-consumption, horse-power, stalling-load of motors, number and force of hammer-blows, etc. The general arrangement of the apparatus is shown in the figure. As we desired pressures varying from 60 to 120 lbs., we stepped up the pressures by pumping the air through a 9-in. Westinghouse pump which had the air-cylinder bushed to a diameter of 7 ins. The air was then pumped into reservoir No. 1, ordinarily with a pressure of 140 or 150 lbs. From here the air was allowed to flow into reservoir No. 2, where it was maintained at any pressure desired by means of a reduction valve. An oil cup containing a thermometer was screwed into reservoir No. 2, and was used to determine the temperature of the air supplied to the tool. Another thermometer was also used to denote the room temperature. From the reservoir No. 2 the air passed through a high-pressure meter and from here was delivered to the tool to be tested, through a 2-in. pipe and 1¼-in. hose. At the point where the air was delivered to the tool we had an expansion, consisting of a 2-in. tee with an internal diameter of about 2¼ ins., in which we determined the pressure by means of a gauge. For the purpose of calibrating the air-meter we used the tank as shown in the figure. The records of time, revolutions of motor, air consumed and strokes of hammer, were obtained autographically, using the record table shown in the figure. In calibrating the meter the method was to have the calibration tank about full of water, and the valve from the meter opened up; the outlet valve was opened, the record paper was started going and record was made as the water in the gauge-glass passed the marks, 5 ins. apart. The meter at the same time made its own record,



TESTING AIR MOTORS AND HAMMERS.

and thus we were able to figure out the number of cub. ft. per contact, or per notch. The various gauges used, from which pressure readings were taken, were previously checked up and adjusted by means of a Crosby dead-weight tester. The arrangement used for testing motors is also shown in the figure. The arrangement was to apply the load by means of a Prony friction-brake, the revolutions being recorded by means of a wiper making contact every five revolutions. The procedure was to first regulate the pressure in reservoir No. 2 at 60 lbs., and then put on a light brake load, keeping this constant during the test with full open throttle. Another test was made with heavier brake load at the same air-pressure, and the increments of load continued in successive tests till the tool was stalled. Then air-pressures of 80, 100 and 120 lbs. were used in the same manner. The arrangement for testing air-hammers is also shown in the figure. The method in general was to let the hammer strike upward against a known weight adjusted to the size of the hammer and to autographically record the distance the weight was lifted. The weights varied from about 40 to 150 lbs., and the vertical lift was multiplied eight times on the record. **M. H. Wickhorst,** *Trans. Am. Soc. Mech. E., Rept. Eng. News, Vol. L, No. 24,* pp. 529-530.

ENGINEERING PHYSICS.

THE paper deals with the results of experiments made in the engineering department of the National Physical Laboratory on the distribution and intensity of the pressure on thin plates and combinations of plates placed in a uniform current of air, and is intended as the first part of a research on the nature and distribution of the pressure of the wind on structures. By a uniform current of air is meant a current in what is known as "eddying motion" as distinguished from stream-line motion, the mean velocity at any point in the direction of flow being uniform across the current. This condition of motion is considered to be the nearest approximation to that of winds of fairly high intensity. The main object of the present research was to determine, if possible, a general relation between the velocity of the current, the dimensions of the plates, and the resultant pressure, as it was felt that experiments in the open air could not be undertaken with any prospect of success until some general relation of the kind had been established. The results of the experiments show that, under the given experimental conditions, a definite relation of the kind existed, and may be stated thus:—For similar and similarly situated plates or combinations of plates in a uniform current of air, the intensity of pressure is the same for the same velocity of current and general atmospheric conditions. On the assumption that the motion of the wind approximates to that of a uniform current as defined above, the above relation shows that the distribution and intensity of the pressure

The Resistance of Plane Surfaces in a Uniform Current of Air.

of the wind on structures may be studied experimentally by means of models of the structures set up in a current of air produced by means of a fan, as in the present case. In illustration of this, the results of experiments made on models of roofs and lattice girders of simple form are given in the paper. Tabulated results are also given for the cases of parallel plates at varying distances apart, plates inclined at varying angles to the direction of the current, and rectangular plates of varying ratio of length to width.—**T. E. Stanton, D.Sc., Assoc.M.Inst.C.E.,** *Proc. Inst. Civ. Eng., Dec. 1903.—C. E. A.*

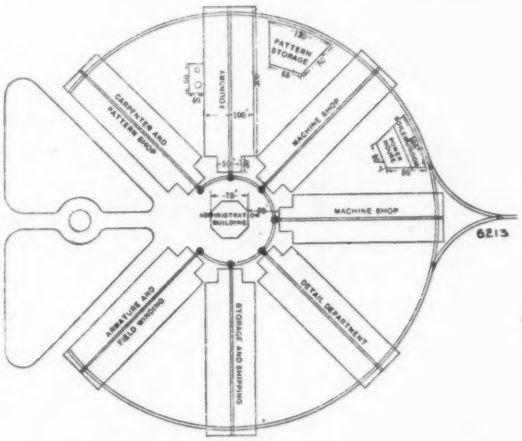
Radio-activity.

THE complex character of the rays from radio-active substances is discussed in this paper, and the different types analysed Three distinct types are known. First we have the α-rays, which have small penetrating power compared with the others. These were at first thought to be undeflected by a magnetic field, but Rutherford has recently shown that with intense magnetic and electrostatic fields they are slightly deviated, and in the opposite sense to that of the β-rays or cathode rays. The β-rays have a power of penetration about 100 times that of the α-rays, and they are easily deflected. In thorium radiation the proportion of β-rays is much smaller than in the case of uranium, and as it is the β-ray which is photographically active, this explains why thorium radiation is much less active on a photographic plate than uranium radiation. Experiments showing the magnetic and electrostatic deflection of the β-rays are described. The β-rays are identified in character with the cathode rays by this deflection, but they have a much greater velocity, which explains their greater power of penetration. An apparatus has been devised by Strutt by which it is possible to show, as a lecture experiment, that these penetrating rays from radium carry off a negative charge. Kaufmann has found a value for their velocity between $2{\cdot}36 \times 10^{10}$ and $2{\cdot}83 \times 10^{10}$ cms. per sec.—*i.e.* between 80 and 95 per cent. of the velocity of light. Theory shows that if the mass of the cathode ray is electrical in origin, and due to the inertia of the moving charge, it should tend to increase as the velocity of light is approached, and become infinite when that velocity is attained; and Kaufmann has found that the ratio e/m decreased from $1{\cdot}31 \times 10^{7}$ when $v = 2{\cdot}36 \times 10^{10}$ to $0{\cdot}63 \times 10^{7}$ when $v = 2{\cdot}83 \times 10^{10}$, so that these results tend to confirm the theory that the mass of the corpuscle or electron is wholly electrical in origin. The third type of rays—the γ-rays—is not deflected so far as is yet known, but these rays are again about 100 times as penetrating as the β-rays. These rays were first noticed in connection with radium radiation, but they have since been found to be emitted also by thorium and uranium.—**F. Soddy,** *Electrician, Vol. LII, Dec. 4, 1903,* pp. 254-255.—*W. C. H.*

CONSTRUCTION.

Suggestions for Shop Construction.

THE plan herein proposed (see Figure) was primarily designed for manufacturing electrical apparatus, and a brief description of the lay-out is as follows: In the centre of the space available for the buildings is located an administration building, constituting the business, accounting, and sales offices; and on the second storey the draughting room, which is hexagonal in shape. The end of each shop, which is nearest to the administration building, has its individual office for the foremen and shop clerks, every shop being then but a short distance from the administration building. The general arrangement gives



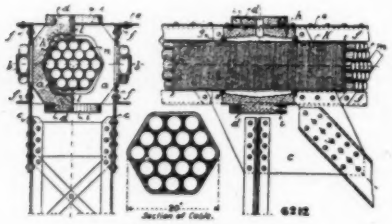
SHOP CONSTRUCTION.

each shop plenty of yard room, and travelling cranes could be located in the yard between any two of the shops. A circular track round the administration building, connected in front of each shop-building by means of suitable turn-tables makes the distribution of material between the buildings very easy, and the distance from any one building to another is comparatively short. At the extreme outer end of each building is another circular track, primarily to be used for shipping purposes, and the distribution of such material as may come in or go out over the connecting railroad lines. This track runs through the end of each building, and in such buildings where the machinery, castings, etc., are to be handled, the heavier travelling crane in that particular building, which should run the whole length of the shop, can easily load and unload the cars. This makes

it possible to go into every shop without having a multiplicity of tracks and switches.—**F. A. Scheffler,** *Trans. Am. Soc. Mech. Eng., Vol. XXV, No. 09.*

Eye-Bar and Cable Designs for Bridge at Cologne.

For a new suspension bridge at Cologne, alternative designs have been worked out, one for an eye-bar cable, and the other for a wire cable. The bridge is to consist of one main span 721·6 ft. long, and two side spans 360·8 ft. long, having one roadway between two trusses 39·4 ft. centre to centre, and two promenades on brackets outside the trusses. The main carrying member of the suspension bridge can be made of a cable of parallel-laid wire or eye-bar links. The wire cable has the advantage of great strength with correspondingly small weight, but the disadvantages of difficult erection and the inaccessibility of the wires. The cable proposed for this bridge would consist of 19 single ropes. According to the drawings the cable is anchored in the anchorages and fixed at the top of the towers which are shown pivoted on roller bearings at the road-level, and the only connection of the stiffening



EYE-BAR CABLE DESIGN.

trusses with each other is by the cable at the top of the towers, the cable forming the upper chord of the stiffening truss. The planes of the cables and trusses are vertical and parallel, and are 39·4 ft. centres. The lower wind-bracing, placed below the pavement, is non-continuous over the piers and takes in the lattice girder and facia of the promenade as its extreme chords. In the case of the other design, the cable is shown of eye-bars cut out of plates, Siemens-Martin steel of 71,000 to 85,000 lbs per sq. in. ultimate resistance, and 18 per cent. elongation being specified. Generally the eye-bars are 15·8 in. by 1 in. Hollow cast or pressed steel pins of about 12 in. diameter are to be used. Each of the two wire cables consist of 19 patent-locked strands of 187,000 lbs. per sq. in. ultimate resistance and 2 to 3 per cent. elongation, with an elastic limit of 115,000 lbs. The greatest stress on the cable is 46,000 lbs. per sq. in. The spaces between the wires in the strands are filled with red lead. The strands in the cables are parallel to each other, and form the cross-section shown in the figure and are held and pressed by a wrapping of square wire. At the panel points the external spaces will be filled by metal fillers. In the attachment of the web members not only vertical panel loads, but web stresses have to be transferred to the cable, and the value of the truss depends on the efficiency of this connection. As the friction devices ordinarily used were found to be unsatisfactory, the arrangement shown in the figure was specially designed. As will be seen two halves of a steel shell *a* are laid round the cables, which are pressed together by rings *I*, forced on projecting shoulders *d*. Attached to this shell are gusset plates *c*, and four angles *f*, which, laced together, form an open box column round the cable. This arrangement makes it possible to erect the stiffening truss without consideration of the cable, and it also distributes the forces tending to overcome the resistance of these boxes to sliding.—**Anon,** *The Rlrd. Gaz., Vol. XXXV, No. 47,* p. 827.

METALLURGY.

Alloys used for Steel Making.

The introduction of chrome-nickel armour-plates lead to the production of a ferro-chrome nickel, an analysis of which is as follows:—Chromium, about 74 per cent.; nickel, about 24 per cent.; iron, from 2 to 2·5 per cent.; carbon, from 0·75 to 1 per cent.; silicon, from 0·25 to 0·5 per cent. It is stated that a chrome-nickel steel, produced by means of this alloy, if worked into armour-plate, acquires, by merely tempering, a superficial hardness equal to that given by the Harvey process. Ferro-tungsten nickel, containing about 74 per cent. tungsten, 24 per cent. nickel and 2 per cent. iron, is used in cases where the simultaneous addition of accurate quantities of nickel and tungsten are required. On the whole, however, this type of alloy has not met with wide adoption. Ferro-tungsten has replaced the use of tungsten powder in the manufacture of tungsten or "self-hard" steels. A normal type of ferro-tungsten is shown in the following analysis:—tungsten, 83·82 per cent.; iron, 10·90 per cent.; carbon, 3·20 per cent.; silicon, 1·87; phosphorus, 0·10; sulphur, 0·11. Tungsten steels are usually manufactured by the crucible process, the tungsten of the product varying from 2 to 10 per cent., and the carbon from 1 to 5 per cent., according to the character of the steel required. The steels are exceedingly hard, and are chiefly made in the form of tool steels. One characteristic feature of tungsten steel lies in its ability to retain magnetism, and the metal is therefore largely used for the manufacture of permanent magnets. A steel adopted for this purpose contains about 7·5 per cent. tungsten, being of normal composition in other respects. A remarkable and interesting compound is that known as "ferro-phosphorus," which is used for a special purpose. It is universally admitted that the presence of phosphorus in steel beyond the limit of 0·1 is deleterious, since it induces "cold shortness." However, in cases where strength and toughness of the steel are not of prime moment, but the properties of freely

cutting and taking a high polish are chiefly required, then a steel of fairly high phosphorus is specially suitable. Steel containing up to 1 per cent. phosphorus is suitable for use in automatic screw-making machines, the products having a very smooth surface, a fine and bright polish. It is, of course, understood that these phosphoric steels made by the use of ferro-phosphorus occupy a field of their own, in which the property of taking a high polish and turning freely are all-important, whilst strength and ductility are of secondary moment. Ferro-molybdenum is prepared by adding the requisite quantity of molten iron to a bath of fused molybdenum. The alloy thus obtained is very pure, and the two metals uniformly mixed. The ferro-alloys thus prepared contain from 50 to 85 per cent. metallic molybdenum, the content being arranged to suit particular requirements. Molybdenum steels made by means of this alloy are claimed to possess properties superior to tungsten steel, and, after quenching in water, the former is stated to be stronger and less brittle than the latter. The ferro-molybdenum alloy has been further improved by the introduction of various percentages of nickel, an alloy used to some extent in the manufacture of steels for forgings, guns, rifle-barrels, wire, boiler-plates and shells. The alloy is added in such a quantity that the finished molybdenum nickel steel contains 0·25 per cent. molybdenum. This amount increases the elongation from 4 to 45 per cent., and the steel is very suitable for the manufacture of plates for high-pressure boilers or boilers of torpedo boats.—**Dr. J. Ohly,** *Mines and Minerals, Vol. XXIV, No.* 5, pp. 211–212.—*P. L.*

Crucible Cast Steel and Tool Steel.

THE production of blister steel by cementation and the crucible process of steel-making are fully described. Emphasis is laid on the care required in the after-treatment of steel, particularly in the hardening and tempering processes.—**R. H. Probert,** *Engineer, U.S.A., Vol. XL, No. 23,* pp. 893–895.—*P. L.*

The Character of the Distortion and Rupture of Iron and Soft Steel.

THE authors in a memoir presented to the Academy of Sciences have endeavoured to group and classify the modes of distortion in iron and soft steels. Iron may be regarded as an aggregate of equiaxial polyhedral grains, each of which may be further likened to the cells of an organised body. Each of these cells is filled with a crystal of iron, crystallised in the cubic system. If the distortion be of such a kind that the structural elements have no influence on the deformation, then the iron may in some respects be regarded as amorphous. It is necessary then to admit that iron simultaneously possesses the three types of structure possible to inorganic bodies, viz., amorphous, cellular, and crystalline. Each of these types may show distortion peculiar to the type. Thus, in amorphous bodies, the distortion follows geometric laws; and this type of deformation is termed "common," because it is familiar to all bodies. With bodies possessing a specific structure the common deformations adapt themselves to the cellular or crystalline structure, resulting in deformations equally specific. In iron the authors distinguish the following types of deformation: (*A*) Common deformations applicable to the cellular structure, this group being subdivided as follows: (1) Microscopic foldings perpendicular or parallel to the direction of the stress. When the distortion has been carried far enough these foldings give place in the interior of the mass to the fringes already noted by Heyn. These fringes appear alternately dark or bright under an equal incidence of light. (2) Oblique foldings, already known to the naked eye as "Lüder's lines"; under the microscope these lines appear of the same nature as the foregoing fringes. (*B*) Purely cellular deformations, which group is further divided into two classes. (*C*) Purely crystalline deformations; this group contains three classes, the chief of which is deformation along cleavage planes. Iron of a cellular structure is very plastic, while iron having a crystalline structure is fragile, and as these two types of structure occur superposed in the same specimen they give rise to facts apparently contradictory. It is this duality which gives to iron its particular position among materials of construction. This duality may also explain the unforeseen fractures which sometimes occur with the metal when in service.—**F. Osmond, Ch. Fremont,** *and* **G. Cartaud,** *Génie Civil, Vol. XLIV, No. 5,* p. 76.—*P. L.*

Tests of Steel for Electric Conductivity, with special reference to Conductor Rails.

FROM a series of experiments conducted on steels of as wide a range of composition as could be commercially obtained, the author submitted a composition suitable for conductor rails to the American Institute of Mining Engineers. For a resistance up to eight times that of copper the specified analysis should be: carbon, not to exceed 0·15 per cent.; manganese, 0·30 per cent.; phosphorus, 0·06 per cent.; sulphur, 0·06 per cent.; silicon, 0·05 per cent. This composition is one that could be readily produced in the open hearth furnace and the resulting steel should present no difficulty in rolling to a suitable shape for conductor rails.—**J. A. Capp,** *Iron and Coal Trade Rev., Vol. LXVII, No. 1863,* p. 1427.—*P. L.*

Elasticity of Circular Plates of Ingot-iron.

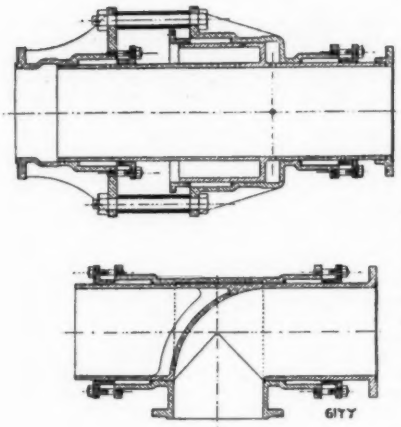
IT is shown by the experiments of the author that there exists a proportionality between the load and the *elastic* deflection up to a limit beyond which the latter will increase more slowly than the load. The *total* deflection, on the contrary, will increase more rapidly than the load from a given value of the latter. It is shown that the co-efficient of elasticity of the discs investigated is partly greater and partly smaller than the one of bars from the same material, this being most likely due to the following causes: (1) The inaccurate knowledge of the

longitudinal tension, as well as of the constants of elasticity of the material in three perpendicular directions; (2) a singular state of internal stress, as due to the rolling process which is altered by annealing; (3) the influence of transverse strains ("Schubkräfte") on the deflection of the disc. Neglecting the latter would result in the co-efficient of elasticity of the disc being found smaller than that of tension bars. Revising the theory of circular discs, the author concludes that any objections which might be raised are incapable of exerting any material influence on the figures found by experiment. In order to establish a still more satisfactory accord between experiment and theory, the isotropy of the material should be more fully accounted for. The accuracy of the theoretical results may anyhow be said to be sufficient, from a practical point of view, within the limits of proportionality; whereas the author is not able to draw any conclusions with regard to the behaviour of circular plates beyond this limit.—**Dr. M. Ennslin,** *Ding. Poly. Jnl., Vol. CCCXVIII, Nos. 50 and 51,* pp. 789 and 801–805.—*A. G.*

PRIME MOVERS.

The Arrangement and Construction of Steam Pipes and their Connections.

THE author in this paper summarises the causes of failure in steam pipes under three headings—faulty design, bad workmanship, defective material. Solid-drawn copper piping of over 6 ins. diam., and of the necessary thickness, is almost invariably of a non-uniform thickness, and possesses a tendency to split longitudinally. This characteristic, seldom developing at the original time of testing, is a cause of extreme danger. So that copper piping of this size should be made up, and should have its thickness increased where bends occur. As brazing injuriously affects the copper, the author concludes that copper should be prohibited for steam pipes over 3 ins. diam., and working under pressures of say 150 lbs. Allowance for expansion is frequently very inefficiently made in a pipe line, and expansion joints should be balanced when used; as, if not balanced, the adjustment of the "preventer" bolts must be very accurately made, or a great strain is brought on the piping either when steam is turned on, or when the piping is cold. Figs. 1 and 2 show good forms of expansion joints, either form being perfectly balanced. A flexible metallic packing should be used in the stuffing boxes of these joints, which should be exceptionally deep. The packing not being then so tightly packed, a freer movement is allowed to the sleeve. The expansion joint in Fig. 1 has an enlargement cast on the sleeve. This forms a piston at the end of the sleeve adjacent to the casting having the large stuffing box. In the sleeve below the piston, holes are drilled which permit the admission of live steam. The area of the piston being made equal to that of the steam pipe, the joint is perfectly balanced. The joint, Fig. 2, is more simple and is used to advantage, where a right angle is required in the main



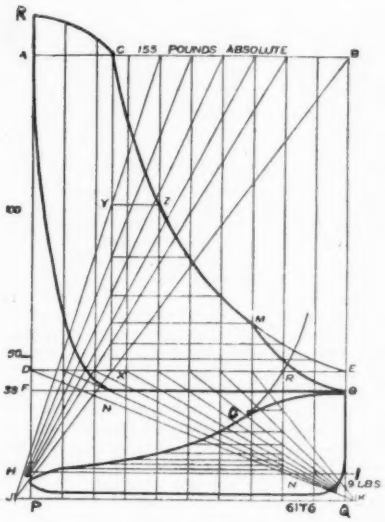
STEAM PIPES.

steam pipe. In the sleeve is cast a deflecting diagram turning the steam into the side branch. Depressions or pockets in the piping, however slight, must be avoided, and separators of ample capacity should be placed near the engine, as, after entrainment of water takes place, no arrangement of piping can carry the water back to the boiler, without the intervention of an efficient separator. The ideal steam-pipe is steel with steel flanges welded to the pipe, each pair of flanges being male and female, and having a wire insertion gasket between them. If too expensive, a good substitute is, when the pipe is expanded and turned over into a recess provided in the flange.—**Robert C. Monteagle,** *Paper Soc. Nav. Architects & Marine Eng., Eng. News, Vol. I., No. 22.*—*A. H. G.*

Theoretical Indicator Diagrams.

CERTAIN conditions of valves, initial pressure, piston speed, etc., bring about certain results in an indicator diagram, and an approximately correct theoretical diagram will serve as a power efficiency and economy basis of much use to the designer and engineer. Here is submitted a method for drawing such cards for a compound engine, given cylinder ratio—cut-off in each cylinder—and clearance volume of each cylinder. In Fig. 1 AB represents to some scale the volume of the high-pressure cylinder, and to another scale the volume of the low-pressure cylinder. Taking PQ as line of no pressures, AB is set off to represent the pressure at cut-off, a suitable drop of pressure RA being allowed from boiler-pressure to allow for wire drawing. C is the point of cut-off in the high-pressure cylinder, and the expansion line CE is drawn by the construction shown. The pole I is chosen so that

$\frac{JP}{PQ}$ represents the $\frac{\text{clearance volume}}{\text{cylinder volume}}$ of the high-pressure cylinder. Assuming pressure at cut-off

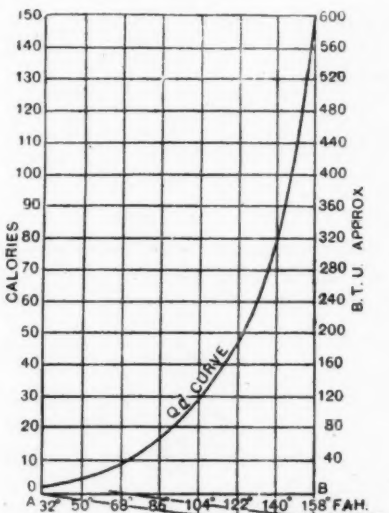


THEORETICAL INDICATOR DIAGRAMS.

in high-pressure cylinder to be 155 lbs.—cut-off in high-pressure cylinder at ¼-stroke—and ratio of cylinder volumes 4:1, the total number of expansions is 16; and terminal pressure in low-pressure cylinder is $\frac{155}{10}$ = 9·6 lbs., say 9 lbs. Drawing the line *HJ* at a height representing 9 lbs., and drawing the line *DE*, join *DK* where $\frac{QK}{PQ}$ represents the ratio $\frac{\text{clearance of low-pressure cylinder}}{\text{volume of low-pressure cylinder}}$. If this line cuts *HJ* in *N*, draw *NR* vertically, and construct the low-pressure expansion curve as shown. If *O* is the point of cut-off in low-pressure cylinder the actual curve will leave the theoretical curve at *O*, and will go as *OG*. A suitable fall of pressure—say 6 lbs.—is allowed from *G* to *O*, and *NG* represents the receiver pressure. Given the points of release *M* and of compression *N* in the high-pressure cylinder, the release and compression curves *MG* and *NA* can now be sketched in. Running a planimeter over the curves gives the mean effective pressure. This is in the high-pressure 54 lbs. and in the low-pressure 18·7 lbs. Reducing both to low-pressure area, we have $\frac{54}{4}$ + 18·7 = 32·2 lbs. We may now from this determine the theoretical weight of dry steam per i.h.p.-hour without any further data, such as size of cylinders. For 1 h.p. = 1,980,000 ft. lbs. per hr., and therefore we must have $\frac{1{,}980{,}000}{144}$ = 13,750 cub. ft. of piston displacement per h.p.-hour at 1 lb. mean effective pressure. So that, with 32·2 lbs. pressure, we require $\frac{13{,}750}{32{\cdot}2}$ = 427 cub. ft. piston displacement per i.h.p.-hour. The weight of 1 cub. ft. of steam at low-pressure terminal pressure being 0·024 lbs., we shall need 427 × 0·024 lbs. = 10 lbs. of steam per i.h.p.-hour. Assuming a cylinder efficiency of 75 per cent., these diagrams, if produced in an engine, would represent a steam consumption of 10 ÷ 0·75 = 13·3 lbs. per i.h.p.-hour.—**E. F. Williams,** *Engineer, N.Y., Vol. XL, No. 23.—A. H. G.*

Condensing Plant for High Vacuum with Limited Water Supply.—I.

THE author concludes that the cooling tower, with or without forced draught, is the best method of dealing with the difficulty caused by limited water supply in the case of electric power stations, evaporative condensers being unsuitable for high vacuum because of difficulty in keeping tight the large number of joints exposed to the atmosphere. For reciprocating engines, when cooling towers are used to supply condensing water at 80 degs. Fahr., maximum efficiency is got with 25-in. vacuum in surface condensers and with 26-in. vacuum in counter-current jet condensers. Cooling towers are usually designed to give condensing water at about 80 degs. Fahr., fan-draught coolers occupying less ground space than natural-draught coolers. One sq. ft. ground area is allowed for 70 gals. circulated per hr. with natural draught—about 400 gals. per hr. with forced draught per sq. ft. The cooling efficiency of a natural-draught tower depends largely on the



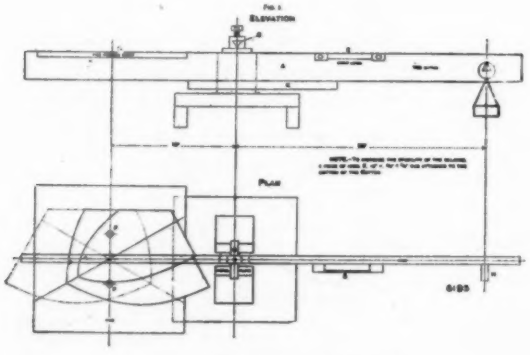
CONDENSING PLANT FOR HIGH VACUUM.

temperature and humidity of air when leaving the cooler, and this mainly depends on the design of cooler and on the duration of contact between air and normal particle of water. The greater part of the cooling is due to evaporation of water, which is greater the higher the mean temperature of air through cooler. The diagram shows the importance of the evaporation factor in total cooling effect. Ordinates from line *A B* to curve represent amounts of heat in 1 kilo of air when saturated at various temperatures. Lines *Q* are drawn at an angle whose tangent is 0·24, this being the specific heat of air at constant pressure. We see that when air leaves at 124 degs. Fahr. it carries away more than 50 per cent. more heat than when leaving at 104 degs. Fahr. As a surface condenser needs nearly twice as much water as a jet condenser, and as delivery from surface condenser is at a lower temperature than that from jet condenser, a larger cooler is necessary with a surface condenser, and more power—probably 75 per cent. more—is necessary to drive fans. Every degree by which the temperature of water leaving the cooler is lowered is obtained with increasing difficulty, while every degree by which we allow the top temperature to rise increases the efficiency of cooler.—**W. H. Roy,** *Paper Manchester Assocn. of Engs., Mech. Wld., Vol. XXXIV, No. 883.—A. H. G.*

NAVAL ARCHITECTURE.

Notes on the Construction of Stability Cross-Curves from Balanced Paper Sections.

THE centre of gravity and area of a surface or number of surfaces can be readily found by means of a small model and light lever balance. It could, of course, be obtained by hanging the body from two points and weighing it. The first method gives the result more quickly, with greater precision and numerical accuracy. The writer has read papers before the Institute of Naval Architects on this subject in 1885, 1886 and 1887, the last one giving a new method of using paper sections for obtaining stability data. One model only was required for all angles and displacements; as however, it was immersed in water at the various draughts and angles, it had to be made water-tight, thus entailing considerable expense. Recently a number of paper models of known form, so that the displacement and righting arms could be rigidly determined, and also models of actual vessels were tested, the centre of gravity and displacement given by the balance being compared with the data obtained by actual calculation with the integrator, the differences in righting arms being so small as to be absolutely unimportant. The models were made of ordinary drawing paper formed in some cases of purely vertical sections, in others of horizontal sections and again by a combination of both. The latter plan gave very good results so far as accuracy was concerned, entailed the smallest amount of cutting, and as the models were not destroyed could easily be used at any time for testing results obtained. In all the sections a centre line was drawn at the required angle and through the assumed *CG*. Two slits about ½-in. long and 4 ins. apart being cut by a penknife in the centre line of the section in order to keep them in position on the balance: the slits were also useful for adjustment. The usual number of sections were used. In all cases it was considered that the trapezoidal rule was near enough when employed in the longitudinal direction. By the employment of horizontal models or sheets, ¼, ½, or ¾, or any intervals could be used, and any variation in lengths of erections could easily be taken into account, as it was only necessary to make the interval proportional to the length. In the vertical models paper sheets were used, having a line passing through the *CG* and to the required angle, and in addition a number of lines drawn at right angles, spaced apart to the various desired draughts of water. In the stability-body-plans, circles were drawn with *CG* as centre, and the radii of the circles corresponding to the various draughts of water at which data was required. In the horizontal models, sheets of prepared paper were used, the centre line in all cases passing through the assumed *CG*; in addition lines were drawn at right angles representing the various draughts of layers of water. The arrangement of the balance can be seen from the illustration. The weights employed consisted of a set of troy weights varying from 1 oz. to ·1 oz. In all tests the unit of weight was ·1 oz. troy. Models of small vessels were made to a scale of ½-in. to 1 ft., and large vessels to a scale of ¼-in. to 1 ft. In the models made of vertical sections



STABILITY BALANCE OF CROSS CURVES.

the displacement and righting arm were first determined for the maximum displacements and then for the lesser draughts by cutting away parts of the models. In other models the displacement and righting arm were first determined for the minimum displacement and then for the deeper draughts by adding parts of the model. To determine righting arm and displacement :—(1) Place model or sections on the drawing board as shown by the full lines on illustration, and balance by known weights ; (2) next turn model or sections over as shown by dotted lines, and balance again by known weights, then evidently by the principle of the lever : (1) $\frac{\text{Diff. of weights}}{\text{sum of weights}}$ × constant = *GZ*, or righting arm in feet ; (2) sum of weights × constant = displacement in tons. The constant to this balance for the righting arm is respectively 40 and 20 for models made to a scale of ¼-in. and ½-in. to 1 ft. and so on. The constant for displacement depends on the scale of the model, and the actual longitudinal interval between the stability sections and weight of paper. For instance a sheet of paper 10 ins. by 10 ins would represent to a scale, ½-in. to 1 ft., a body of water $\frac{20 \times 20 \times \text{long. int. in feet}}{35}$, or to a scale of ¼-in. to 1 ft., a body of water

$$\frac{40 \times 40 \times \text{long. int. in feet}}{35},$$

and so on. the paper is therefore weighed, then the $\left\{\frac{\text{displacement}}{\text{weight of paper in units}}\right\}$ = tons displacement per unit of weight. The distance 20 ins. on the top of the batten between the two knife edges is divided into ten divisions and each of the latter is again divided into ten parts. Very small weights are thereby dispensed with. Thus ·1 oz. on No. 4 mark would represent ·04 oz. placed in the pan. Again ·1 oz. on the 5·1 mark would represent ·051 oz, placed in the pan ; ·0005 oz. troy could easily be measured. *FF* are small French nails for keeping model in position on board.—**John H. Heck,** *Trans. Inst. of N. E. C. Inst. of Engineers and Shipbuilders, Vol. XX, 1903.—H. B. D.*

Coaling at Sea.

One of the most important problems of modern naval warfare is the question of coaling ships at sea. The most interesting proposition recently made is that on the part of Great Britain to build four colliers having a speed of 18 knots each, of a carrying capacity of 10,000 tons of coal each, and equipped with the latest coaling devices. Such colliers would accompany a fleet and thereby give much wider scope for operations. The Cunningham-Seaton proposed method, as described by the author, consists of two pipes arranged transversely below the water-line, about half-way between midships and each end, so that when a collier is brought alongside a warship a constant and safe distance is maintained between them by means of a water jet. These pipes may be fitted to either the warship or collier, and the jets produced by means of the circulating, fire, and bilge pumps. The disposition of valves is such that either side of the vessel may be utilised for working the coal. The required distance between the ships is secured by lines passed between the vessels, for there are no rigid connections of any description. It is not intended with this apparatus that any appreciable lateral speed should be produced—a tendency to separate the vessels sufficiently to keep the connecting lines taut is all that is desired or necessary. It is not necessary that the jet of water should reach from one ship to another : the reaction of the jet upon the surrounding water is sufficient to produce the tendency to separate. The momentum of the water jets is imparted to the ships by reaction, and when a tendency to move or a slight motion has been produced the momentum of the ship for resisting wave action is very great. The resistance of the ship to which the connection is made to moving sideways through the water completes the combination. Mr. William Seaton, M.E., of C. W. Hunt & Co., has proposed a coal-conveying apparatus for use with the water-jet device. The necessary arrangements for securing the vessels alongside having been made, a boom is rigged out and coaling proceeded with. For the most rapid operation the coal is taken from the hold of the collier with a grab-bucket, dumped into a hopper on the ship, and from thence conveyed to the coal shoots in cars. By giving the water-jet apparatus as much power as installed in an ordinary tugboat, valuable manœuvring properties may be secured which have not hitherto been possessed by ships, and thus make the water jets valuable at all times. The tactical diameter would be reduced by such an installation. Direction of the vessel could be changed or maintained in action or on blockade without longitudinal motion. Docks could be approached and left with greater facility and safety, and a purely lateral motion could be obtained when desired. —**Civil Engr. A. C. Cunningham, U.S.N.,** *Jnl. Am. Inst. Naval Engr., Vol. XV, No. 4,* pp. 1057-1064.—*H. B. D.*

MARINE ENGINEERING.

Marine Propellers with non-reversible Engines and Internal Combustion Engines.

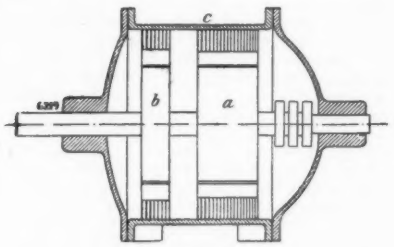
The author deals in an interesting manner with other methods of propulson than the screw, and describes the various methods of employing the screw propeller. There are five systems whereby a vessel may be propelled and controlled when driven by a non-reversible motor :—(1) By means of a screw-propeller with moveable reversible blades operated by a sliding-rod through a hollow shaft (a favourite method for small craft). (2) By means of a screw-propeller and mechanical reversing gear, usually in the form of a friction clutch and spur

wheels. (3) By two screws, right- and left-handed, connected by a sliding-rod through a hollow shaft, whereby either screw may be loose, and the other locked or driven, or both locked or loose. (4) By means of electrical control, the engine driving a dynamo and motor driving a screw. (5) By water-jet propellers. The first system is typically illustrated by the propelling gear of small vessels built by Messrs. Vosper, of Portsmouth, and driven by oil-engines using ordinary paraffin oil. The blades are reversible by a lever and screw worked by a hand-wheel. A similar method is adopted by the Mitcham Motor Company of Cowes. It is perfectly satisfactory for very small powers with screws up to about 2 ft. diar. The second method is often used for larger powers. One form of reversing gear consists of the three bevel wheels and two friction clutches working inside the wheels. A lever is applied to throw the clutch in or out of gear. The engine shaft does not extend beyond the first bevel wheel, which is either keyed to it or forms part of the engine fly-wheel. The third method has been adopted by the "Griffin" oil launch and boat builders. It consists of two propellers, right- and left-handed pitch respectively, the forward propeller being mounted on the end of a hollow shaft which extends to the interior of the boat. A second shaft passes through this hollow shaft, the end being mounted on the sternmost propeller. A double friction clutch attached to the engine shaft, and actuated by a hand-lever, is connected with the ends of the shaft in the interior of the boat, the arrangement being such that either of the propellers may be engaged with the engine, or both simultaneously disengaged. With the fourth system the power is transmitted electrically to a motor on the propeller shaft. In this method the propeller shaft may be long or short and the motor placed as far aft as possible, while the engines and dynamo can be placed forward. The fifth system is not new and has been used in some vessels with success. In this system the water-jet propeller is used. The efficiency depends to a large extent upon the sectional area of the jet being a very large fraction of the midship section. The features, advantages and disadvantages are fully discussed. The fourth system merely differs from the ordinary common drive screw, but with an electric generator and motor interposed. The paper is concluded with a reference to the possibility of working internal combustion engines reversible. This can be done with success by the three-cylinder Bertheau engine and with one or two other designs of oil-engines. In these reversing internal combustion engines, compressed air or compressed burnt gases are stored in order to be drawn upon for starting, and the engine valves are adjustable by levers and cams so that they run normally as four-cycle engines, but start with compressed air or gases, as two-cycle compressed-air engines. For powers larger than about 80 h.p. there is but little experience to go upon—but there is a choice between: 1st. The oil-engine manœuvred and controlled as a compressed-air engine when starting and reversing. 2nd. The water-jet propeller and pump. 3rd. The electric motor with dynamo on the engine and a motor on the propeller.—**Mr. Rankine Kennedy,** *Trans. of Inst. of Engrs. & Shipbdrs. in Scotland, Vol. XLVII., Part II., 1903–4,* pp. 29–42.—*h. B. D.*

ELECTRICAL ENGINEERING.

Single-Phase Motor without Collector.

Dr. Corsepius, eight years ago, designed a single-phase motor in which the problem of imparting a starting-torque to ordinary single-phase motors without collectors was solved by connecting the various motors of the same plant by means of a third wire. The motor described in this paper avoids the drawback presented by this system—namely the dependency of the motor on other motors, possibly located at different points, as well as the third wire connecting the motors. The new motor, while being devoid of a collector, is started at low-current intensities with a multiple of normal loads without depending on any other motors or requiring a third wire; its efficiency is very satisfactory. The motor is an asynchronous single-phase motor with two rotors—namely a principal rotor *A* and an auxiliary rotor *B*, both rotating in the stator *C*. The main rotor is rigidly connected to the shaft, whereas the auxiliary rotor is loose; moreover, the principal rotor has sliding rings, whereas the auxiliary rotor has short-circuit windings. In order to ensure a starting under load the author utilises the properties of asynchronous single-phase motors. The rotation in a given direction as once established will result in a magnetic alteration depending on this direction; the apparent resistance of any two portions of the windings of the stator at a given moment, so far from being constant, is continuously variable. The author accordingly divides the whole of the stator coil into two equal portions, being displaced with respect to one another by 90 degs., so as to utilise the diversity in the apparent magnetic resistance of the two portions, in order to influence the current supply by connecting them in parallel or in series with other points of the winding. The auxiliary rotor serves to give rise to the above difference in resistance, whereas the main rotor evolves power, the portion of the stator surrounding it being traversed by two currents depending on the above behaviour of the resistance in the portion of the stator enclosing the auxiliary rotor. The above effect is obtained only in the case of the auxiliary rotor rotating, a small rheostat serving to start the latter as in the case of asynchronous single-phase motors without load. The Ernst Heinrich Geist Elektricitäts A.G., Cologne, has constructed an experimental motor of a normal output of 5 h.p. for a tension of 140 volts. The stator is made up of two sheet-metal bundles corresponding to the main rotor *A* and the auxiliary rotor *B*, which are of the same bore, whereas the breadth of *A* is about double that of *B*; a choking coil in connection with a rheostat serves to start the motor. The rotor *B* has a coil of various copper ribbon loops, being



SINGLE-PHASE MOTOR.

short-circuited and surrounding the rotor. The rotor *A* has wire windings. Though this experimental motor was in many respects of an unfavourable design, the results so far obtained are rather satisfactory. In the case of the auxiliary rotor running alone, 16·3 amps. are consumed at 138 volts, 60 amps. being necessary in the starting, which occurs most rapidly. In the case of the main rotor, running also at no load, 44 amps. were consumed at 140 volts, whereas in the case of a load as high as 4·2 h.p. a consumption of current of 57 amps. was noted, with 141 volts. The following figures were further observed :

(1) Motor in operation—

H.P.			Amps.
2·4	...	...	48·5
4·62	...	...	57·0
6·83	...	...	68·4
7·95	...	...	72·6
9·05	...	...	78·4

(2) Starting under load according to the following h.p.—

H.P.			Amps.
2·4	...	...	48·0
4·62	...	...	65·6
6·83	...	...	86·2
7·95	...	...	97·0
9·05	...	...	97·0

From these values of the current intensity, observed in the instant of starting of the braked motor, it will be inferred that the increase of current as compared with regular operation is relatively very low. Similar results are obtained in the case of a freed starting (without braking). Experiments made on the above motor go to show that it is possible to design motors starting with multiple overloads at low-current intensities while possessing a high efficiency ; these motors are, therefore, available also for railway operation.—**Dr. Max Corsepius,** *Elektrotechn. Zeitschr., No. 50, Dec. 10, 1903*, pp. 1012–1014.—*A. G.*

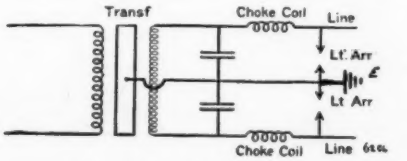
Single-phase Current Traction.

In former articles the author had shown the possibility of solving the problem of electric traction by single-phase current with three different types of collector motors ;* all of which would allow of working in synchronism. The author discusses a method of torque control, presuming the motors to be branched off immediately from the mains under constant pressure. It is pointed out that both the magnitude and sign of the torque will exclusively depend on the adjustment of the brushes on the collector. It will therefore be possible, by a convenient regulation of the brush holder, to obtain at any time either the positive or negative torque for a given speed, so as to ensure any desired speed and to effect the recovering of work, and braking from full speed down to stopping without the least loss in energy. In order to avoid such mechanical complications as might arise from the handling of the brush-holder, the author suggests providing the stator with a device analogous to a collector. The author purposes describing, in a forthcoming paper, his method for obviating the difficulties experienced in starting collector motors with alternating current on account of possible short circuits in the brushes at low speeds.—**M. Latour,** *Elektrotechn. Zeitschr., No. 51*, pp. 1,027–1,028. —*A. G.*

* See *Elektrotechnische Zeitschrift*, 1903, pp. 453, 877, and 109.

Static Discharges in Electric Circuits.

Static waves are set up in commercial circuits whenever a live wire is connected to a dead one, or is accidentally earthed, or is short-circuited with another one, or when a switch is opened, or a lightning-arrester discharges, or any other disturbance occurs which causes an abrupt change of potential, either up or down. In all such cases the discharges are usually oscillatory but not very persistent, and under the most favourable conditions the induced potential is not built up by resonance to more than two to three times its initial value ; while ordinarily it is not increased by more than about 50 per cent. These conclusions are partly based upon theory, but have also been confirmed by the author by actual tests in large installations of various voltages and lengths of circuit. As a rule disturbances produced by lightning do not exceed those proceeding from the other causes mentioned. Exceptionally, when lines are directly struck by lightning, the local rise of potential may be more than any commercial arresters can deal with, and it reaches the earth by the nearest and shortest path ; but the generating station can generally be protected by suitable appliances from the effects of the static waves set up, unless the stroke is in its immediate neighbourhood. Most of the causes of static waves only act momentarily, and their potential is not sufficient to throw great strain upon solid insulating materials ; but air spaces and surface distances are very readily broken down, and a large margin should be allowed in these respects in the design of all high-tension stations. The striking distances



STATIC DISCHARGES.

of potentials from 20,000 to 100,000 volts increase much more rapidly than the pressure. The strains due to "local concentration of potential" when static discharges of high frequency reach apparatus —such as transformers— whose inductance and capacity is enormously greater than the rest of the circuit are far more severe than these previously mentioned. They are very liable to start sparks between the layers of the coils and so open a path for the main current; and breakdowns from this cause are very frequent. Such effects may be checked by choking coils, but not without seriously interfering with the normal operation of the system. Branch circuits also help to break up the waves, but to be really effective they must be so long that their cost is prohibitive. Lightning arresters are the only devices at present in practical use for preventing such occurrences, and they should have a resistance in series with them, so that the static discharge may not be followed by arcing over the arrester and a considerable flow of current. The author recommends the employment of what he terms "low-equivalent arresters," in which part of the series resistance is shunted by a second set of air gaps. Thus, while only the balance of the resistance impedes the passage of a static discharge —which prefers to spark across the gaps rather than follow through the resistance—the whole resistance is available to stop the flow of current at the normal potential. For very high-pressure circuits static interrupters should be introduced to prevent the destruction of machinery by local concentration of potential. They consist of comparatively small and very heavily insulated choking coils, and are connected in the main circuits close to the apparatus to be protected, with the addition of a condenser having one pole joined between the two and the other to earth. The figure shows this method as applied to the protection of both poles of a transformer. Considerable heat is generated in condensers used in this way, and provision must in consequence be made for a free circulation of the oil insulation. Besides the practical conclusions, the earlier part of the paper is occupied with a consideration of wave motion in general; and the properties of and laws governing electric waves are illustrated by analogy with those produced by sound, light, etc.—**Percy H. Thomas,** *Jnl. Franklin Inst., Vol. CLVI, No. 5,* pp. 387-398; *No. 6,* pp. 433-452.—*E. J. W.*

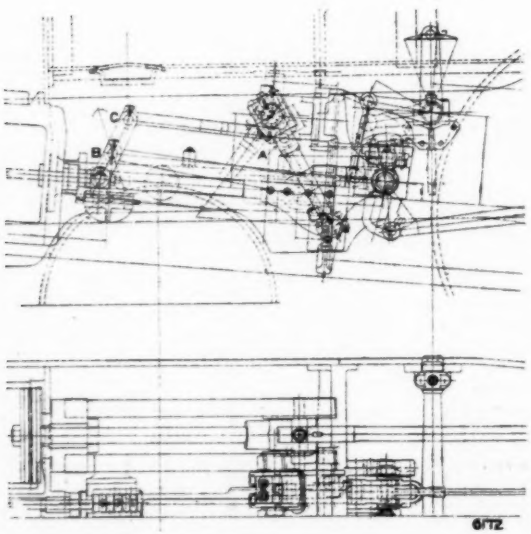
LIGHTING, HEATING, AND VENTILATING.

TRACTION.

The Renard Automoblie Train.

The author gives a full account, with detailed drawings, of the Renard automobile train with continuous propulsion, for use on ordinary highways. The principle may be thus described. To a light but powerful road-locomotive is attached a train of wagons, to each of which power is communicated by a revolving shaft with universal joints. This articulated shaft runs the whole length, actuating the wheels of each truck by suitable gearing. Steering round curves is effected by a pivoted rod passing from the rear of each wagon to a pin in the front axle of the next, and branches from the rod are attached by levers to each wheel, so that they are guided in the desired direction. Flexibility on curves and gradients is ensured by spiral springs enclosed in cylindrical boxes fixed on the shafting or the axles, one end of the spring being attached to the box and the other to the mechanism. A brake on the motor affects the motion of the entire line of shafting, therefore the braking of all the vehicles is under the control of the driver. There are three sets of gear speeds, and a further special device to vary the rate of speed according to the load.—**Lt.-Col. G. Espitallier,** *Gen. Civil, Vol. XLIV, No. 1123,* pp. 97-101.

Fig. 1



VALVE GEARS.

Improvements in Valve-Gears.

The object of this paper is to represent the advantage to be gained by a method of securing a long dwelling movement to the valve not at the ends of the stroke but

at half stroke of the valve. The necessity for improvements in valve-gears was brought to the author's notice when conducting experiments with his continuous expansion system as applied to compound locomotives, which requires that steam should be cut off very early in two high-pressure cylinders as against the existing practice of cutting off late in one high-pressure cylinder. It was found from actual results when using both the Stephenson and radial type of gear, that the benefit which might have been expected from the use of a wide range of expansion due to the very early cut-off was not realised, owing to the exhaust passages of the high pressure cylinders being closed too early, thereby boxing up the steam in the high-pressure cylinders instead of allowing the same to expand freely to do work on a large low-pressure piston. It was this defect in valve-gears that induced the author to go carefully into the problem of devising some means of improving not any one particular type, but all forms of valve-gears. From the figure it will be noted that a separate lever is made use of to control the lap and lead. At first sight one would naturally take it to be a combination of the Joy and Walschaert form of gear, but this is not the case, for the improvement can be applied to the Stephenson link motion and to many others. The improvement claimed is attained by varying the length of the short arm of the lap and lead lever during the stroke. This is accomplished by allowing the short arm to slide in a slipper block rocking in a bracket, the latter being a fixture. This has virtually the effect of reducing the length of the short arm to a minimum when the piston is at half stroke. Thus a long dwelling motion is given to the valve, which allows the steam to do work on the piston during a greater length of the stroke, and also keeps the exhaust passage open later at the opposite side of the piston. Any delay in the movement at half stroke has to be made good when nearing each end of the stroke, and this arrangement results in accelerating the movement of the valve to steam admission and exhaust, so that it becomes practicable to have a large port opening, giving at the same time a rapid cut off when the gear is linked up.—**J. Reikie, M.Inst.C.E.,** *Proc. Inst. of Engs. & Shipbldrs. Nov. 1903.—C. S. L.*

MECHANICAL.

A New Mechanism.

FOUR-PIECE mechanisms composed of turning pairs either have the axes of rotation all parallel to one another or all meeting in a point, and any other disposition of the axes is known usually to produce a chain of four pieces which is completely stiff and so supplies no mechanism at all. In this paper, however, the author points out and describes an exception to this rule, providing the missing case of a skew mechanism having the axes of rotation neither parallel nor concurrent. After discussing the essential geometric features of any one of the links composing a skew mechanism of turning pairs, the author describes the movement, showing the relation between the angles of rotation of the two cranks, and indicates the varieties of geometrical form which the mechanism may take, and also the varieties of material form which may be given to it.—**G. T. Bennett,** *Engineering, Vol. LXXVI, No. 1979,* p. 777.—*W. C. H.*

WORKS MANAGEMENT.

The Operation of Isolated Plants.

IN this paper the author deals with the systematic operation of steam and electric plants, including under this head the employment and regulation of the engineer and his staff; the recording and tabulation of the work done by the plant, of the conditions under which the work is done, and of the material and labour required to produce it; the purchase of supplies, and periodical inspection. A complete system of organised control is propounded by the author, the object of his method being to produce results at the least cost consistent with continuous and reliable operation.—**P. R. Moses,** *Eng. Mag., Vol XXVI., No. 3,* pp. 410–419.

WATER AND SANITARY.

Deposits in Pipes and other Channels conveying Potable Water.

THE paper dealt with three classes of deposits—(1) Incrustations on iron pipes: their source, causes, and remedy; (2) growths, more or less slimy, on inner surfaces of pipes and culverts and tunnels; their varieties, nature, composition, and causes; also the composition of waters which produce different kinds of growths; (3) loose deposits. Analyses were given of incrustations on iron pipes, and analyses of different kinds of waters were quoted, showing that these incrustations were due to oxidation of the iron of the pipes, whether widespread or in nodules, and that they were not limited to acid waters, but were common to acid, alkaline, and neutral waters. The remedy was briefly discussed, in the light of recent experiments as well as earlier observations. Growths or deposits on the inner surface of pipes were of two kinds:—(*a*) Deposits of carbonates of alkaline earths from calcareous waters; (*b*) black slimy deposits, from the top, bottom, and sides of pipes and other channels conveying certain waters, chiefly from Welsh sources. Investigations were recorded, and detailed evidence was adduced, showing that these slimy deposits were produced by gelatinous and filamentous iron-organisms which grew and extracted iron from the water, and died at one end while they grew at the other. Solid rock particles were entangled in this slime, and binoxide of manganese was deposited by chemical action, and this also was entangled in the mass of the gelatinous iron-organisms. Analyses were given of waters which did, and a variety of waters which did not

support the growth of this slime, and deductions were drawn as to the constituents of the waters on which these growths depended. Experiments were described, undertaken with the view of ascertaining the conditions favourable to the growth and the conditions which would prevent the multiplication of these organisms and the growth of the slime. Microphotographs were given of these growths at different stages, and the results of the experiments were described and discussed, in order to arrive at a correct theory, and so at a practical result. — **Prof. J. Campbell Brown, D.Sc.,** *Proc. Inst. Civ. Eng., Dec. 1903.—C. E. A.*

The Purification of Water Highly Charged with Vegetable Matter.

THIS paper treated of the nature of tropical waters collected in regions free from ordinary sources of contamination, but containing large quantities of dissolved vegetable matter. These waters, wherever their place of origin, presented a great similarity of composition, samples from Mauritius, the West Coast of Africa, Uganda, and the West Indies having the same characteristics. In all cases contamination was caused by the water remaining stagnant or flowing slowly through regions rich in vegetation, which by its decay produced a large quantity of vegetable *débris* absorbable by the water. Pure tropical waters might be obtained even from a district densely covered with vegetation, provided that the flow was sufficiently rapid. The purification of waters of this class was very difficult. The authors had found by experiment that treatment with iron was generally efficacious, but the treatment must be more thorough than was necessary with ordinary water supplies. The peculiar character of these waters charged with vegetable matters rendered the removal of the iron difficult; casual aëration by fountains or cascades was insufficient. Systematic aëration, so as to ensure an abundant supply of oxygen, was requisite. Various methods had been tried, and finally an apparatus had been devised in which the water was caused to flow through perforated plates, emerging in streams of small diameter, and exposing so large a surface per unit volume of liquid that rapid absorption of oxygen from the air was made certain. It was found that, if the water was delivered at or above a certain critical head, the streams of liquid remain distinct, and if they were caused to coalesce by some temporary disturbing influence, such as a gust of wind, they resumed their position and individuality as soon as the disturbing influence had subsided. The use of this critical head was essential for the proper working of the apparatus, and for the satisfactory aëration of the water. Plant designed on this principle had been erected to purify the water supply at Mauritius and in Uganda; the method had sufficed to change water so loaded with vegetable matter as to be almost unpotable, into a drinking water of excellent quality. An account was given of the waterworks at Mare aux Vacoas in Mauritius, and of the various improvements in the mode of purification which had been effected from time to time. The principle of aëration had also been usefully applied at Singapore by means of intermittent filtration, but the authors held that the systematic process described above was preferable on account of its certainty and compactness. They considered that by this means it was practicable to purify difficult tropical waters so as to obtain a satisfactory supply without excessive cost or difficulty of working.—**O. Chadwick, C.M.G., M.Inst.C.E.,** and **B. Blount, Assoc.Inst.C.E.,** *Proc. Inst. Civ. Eng., Dec. 1903.*

The Brussels Water Supply.

THIS paper deals very fully with the water supply of the Brussels district, in which there are three distinct water services: (1) That of Brussels, supplying the needs of more than 300,000 inhabitants in the communes of Brussels, Etterbeek, Uccle, and Molenbeek-Saint-Jean; (2) that of Laeken, established in 1898, supplying 20,000 inhabitants on the left bank of the Brussels and Willebroek Canal; (3) that of the Compagnie Intercommunale des Eaux, serving 16 communes, with a population of about 363,000 inhabitants. —**A. Deblon,** *Ann. des Trav. Publics de Belgique, Fascicule 4, 1903,* pp. 1–116.

Filter Wells.

THE author says that by this title are commonly signified well-installations, that filter or do not filter with cylindrical or prismatic tubbings, perforated or furnished with strainers, sieves, or permeable materials, and which, situated in water-yielding strata, are used for furnishing water for domestic and industrial purposes. Filter wells are generally of small cross-section, but are equally applicable to the supply of water on a large scale. The author then describes the ordinary, old-fashioned well, various methods of tubbing, and the most suitable manner in which wells may be applied in public waterworks, illustrating his paper with a number of sectional drawings and diagrams.—**T. Verstraeten,** *Ann. Ing. Gand., 3me Ser., Tome II., 3me Fascic.,* pp. 227–252

The Riedler Pump.

WHILE investigating the general action of pump valves, Professor Riedler found the benefit arising from the operating of these valves by mechanical means, with the result that he obtained much higher plunger speeds, and in consequence was able to reduce the size of the plant for a given duty, as well as the space occupied, and also to diminish the loads and shocks on the working parts. In many cases the engine driving pit-work is geared to the crank-shaft of the pump, and by this means the engine can get away at a higher speed, but then the gearing has to be taken into account, both for friction and also for cost. A plunger-speed of 100 ft. per min. used to be looked upon as a fair speed, but in Riedler pumps speeds of 500 ft. per min. are common, and some plants even run, when required, at 640 ft. per min.—**H. D. D. Barman,** *Trans. Inst. Mining Eng., No. 1,040, 1903.*